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STUDY OF INTERCITY

SURFACE TRANSPORTATION ALTERNATIVES

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17. Abstract

While almost all modes of intercity passenger transportation in Canada involve some degree of public subsidy, rail passenger services represent a particularly serious financial burden, especially since on many routes the bus offers service faster and more frequent than that of the train. This study was initiated in response to such concerns. Its objective was to identify, based on cost performance, the most appropriate applications for each of these two modes within the intercity passenger transportation system. Cost models were developed by correlating key performance variables with cost accounting data. The rail cost model covers three types of equipment currently in service; the bus cost model is based on data for a standard 40 ft. (12 m) coach, but also allows for the consideration of high-capacity buses and innovative types of service with a level of comfort equivalent to that of a train. The models were applied to seven Canadian routes of various lengths (200 to 1350 km) and passenger densities. In all cases the cost of rail service was substantially greater than that of bus service. In a comparison of scenarios in which either rail or bus carries all the surface mode passengers, rail costs were estimated at 6.4 to 16.3¢/seat-km, bus costs at 1.7 to 6.7¢/seat-km.

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17. Résumé

Bien que presque tous les modes de transport interville de personnes au Canada doivent être subventionnés d'une manière ou d'une autre, il s'avère que le transport ferroviaire de personnes constitue une charge financière particulièrement lourde, surtout que sur bon nombre des liaisons actuelles, l'autobus pourrait offrir un service plus rapide et plus fréquent. L'étude dont le présent rapport rend compte a été lancée afin d'approfondir cette question; son but était de rechercher les liaisons types pour la desserte desquelles ces deux modes de transport sont le mieux adaptés, le critère retenu étant le coût du transport. Des modèles de coût ont été élaborés, mettant en corrélation les principaux paramètres de fonctionnement, d'une part, et de coût, d'autre part. Le modèle relatif au transport ferroviaire a pris en compte trois matériels couramment en service; celui du transport routier a été fondé sur l'autocar classique de 40 pieds (12 m), mais permet aussi de considérer des nouveaux matériels grande capacité et des services novateurs offrant un confort comparable à celui du train. Les modèles en question ont été appliqués à sept itinéraires canadiens différenciés par la distance totale (entre 200 et 1 350 km) et le volume de la clientèle. Il a été constaté que, dans tous les cas étudiés, le coût du transport ferroviaire était sensiblement supérieur à celui de l'autobus. En situation de monopole, c'est-à-dire un scénario où les voyageurs empruntant un mode de surface seraient tous transportés par train, ou par autobus, il a été trouvé que la place-kilomètre coûterait entre 6,4 et 16,3¢ dans le cas du train, et entre 1,7 et 6,7¢ dans le cas de l'autobus.

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EXECUTIVE SUMMARY

Study Objectives

While almost all forms of intercity passenger transportation in Canada involve some degree of public subsidy, there is a general perception that rail passenger services represent a significant financial burden to the federal government and that, of the routes served by the rail system, many are also served by buses which offer service frequency and speed superior to that of the train.

In response to such concerns, the Transportation Development Centre, Transport Canada, initiated a study to identify the most appropriate applications for rail and bus services within the intercity passenger transportation system.

The primary objectives of the study were defined to be as follows:

- To compile objective information on rail and bus costs;
- To develop a methodology by which to compare the relative cost of intercity rail and bus passenger transportation; and
- To determine those conditions under which each of the two modes exhibits the comparative economic advantage with respect to cost performance. The range of conditions assessed included traditional buses, high capacity buses and innovative types of bus service which provide an equivalent service to rail in terms of comfort and space.

Study Approach

The study approach consisted of the following major tasks:

- Development of simplified interactive computer models to estimate rail and bus costs.
- The application of these cost models to a range of typical Canadian markets. The range of conditions assessed included alternate routes and service attributes as well as alternate forms of bus technology, i.e., fuel efficient and high capacity buses.
- Synthesis of the results and development of findings with respect to intramodal and intermodal choice.

Description of the Rail Cost Model

The rail cost model is based on VIA Rail's reported operating costs for 1980 and 1981.

Using additional information obtained from the CTC and from other published documents, unit costs were developed by specific service (high density corridors, low density corridors, and overnight service), and by individual type of equipment (RDC, LRC and conventional).

The data was arranged into the following major functional cost accounts:

- o Capital cost of rolling stock
- o Train operations
- o Track related operations
- o Other services
- o Overhead

Description of the Bus Cost Model

Costs for conventional buses (i.e., 45-passenger MCI bus) were established using aggregate Class 1 and 2 carrier cost data for 1974 to 1980 published by Statistics Canada; Grey Goose Bus Co. cost data for 1981 to 1983; and Travelways Maple Leaf Limited intercity route cost data for 1982 and 1983.

The costs were grouped into the following major cost categories:

- o Driver Expenses
- o Vehicle Expenses
- o In-Vehicle Service Expenses
- o Terminal Expenses
- o Maintenance Expenses
- o Administrative and General Expenses

Six alternate bus scenarios were considered in this investigation. They include the conventional technology; conventional buses with innovative attributes which provide an equivalent service to rail in terms of comfort, space and on-board services; high capacity buses and technological alternatives to the conventional bus which are considered feasible in the short term.

Category	
o Conventional Bus	(1) 40' Bus, 45 Seats
o Conventional Buses with Innovative On-Board Attributes	(2) 40' Bus, 30 Seats
	(3) 40' Bus, 22 Seats On Board Attendant On Board Meal Service
o High Capacity Buses and Technological Alternatives	(4) 40' Bus, 45 Seats Improved Fuel Efficiency
	(5) 45' Bus, 53 Seats Improved Fuel Efficiency
	(6) High Capacity Bus, 75 Seats

Factors were selected, based on the published literature to convert the conventional MCI bus cost accounts to specific unit costs representative of these individual types of service and technology.

Application of the Cost Models

The rail and bus cost models were applied to a range of typical Canadian markets.

Seven intercity routes were selected for study. They include one link in the Atlantic Region, two in the Quebec City - Windsor corridor and four western routes. The seven routes, identified below, include short, medium and long haul runs, and both low and high passenger densities.

Link	Region	Description
Montreal - Ottawa	Corridor	Short Haul - High Density
Regina - Saskatoon	Western	Short Haul - Low Density
Sydney - Halifax	Atlantic	Medium Haul - Low Density
Toronto - Montreal	Corridor	Medium Haul - High Density
North Vancouver - Prince George	Western	Long Haul - Low Density
Winnipeg - Thompson	Western	Long Haul - Low Density
Winnipeg - Edmonton	Western	Long Haul - Low Density

The rail and bus cost models were applied individually to the selected routes on the basis of existing mode specific service frequencies and passenger flows, and a comparison of the "within mode" advantages was carried out. The models were also applied on the basis of equal passenger flows thus providing opportunity for a comparison of cost performance "between modes".

The results of the tests include a summary of the annual operational performance expressed in terms of annual seat-kilometres, annual passenger-kilometres, and average passenger load factors, and of the annual cost performance in terms of total annual operating costs and unit operating costs per seat-kilometre and per passenger-kilometre.

Rail Performance

Of the three types of rail equipment considered, LRC's operating on high density short haul routes exhibit the lowest operating costs.

RDC's exhibit the lowest operating costs on low density routes not requiring sleeping accommodation. Conventional rail equipment featuring dayniters and sleepers appears to be the most appropriate type of equipment on overnight routes.

Bus Performance

Of the six scenarios tested, Scenario 4, a fuel efficient bus (45 seats) and Scenario 5, a slightly longer fuel efficient bus (53 seats) consistently exhibited the lowest operating costs.

Scenario 4 exhibited the lower of the two sets of values on low density runs, while Scenario 5 exhibited the lower values on the high density routes.

These results suggest that the maximum improvement in cost performance can be derived by directing efforts towards one major area, specifically the development of improved fuel efficient engines. Also, there is an additional marginal benefit to be gained by the development and operation of larger buses on high density routes (i.e., 53 seaters). The results of this investigation suggest that there is no significant benefit to be gained by going to 75 seat buses.

Similarly, there is no comparative advantage to be gained by operating high capacity vehicles on low density routes - where 45 seat buses provide ample seating capacity or by operating reduced capacity vehicles on high density routes.

There can be a cost advantage by operating reduced capacity vehicles in the range of 30 seats on low density routes provided complementary marketing efforts are initiated.

Comparison of Rail/Bus Performance

Of the two modes, rail is shown to be significantly more expensive. Regardless of route, service frequency or ridership, all of the bus scenarios considered offer the comparative advantage with respect to cost performance.

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1. INTRODUCTION

While almost all forms of intercity passenger transportation in Canada involve some degree of public subsidy, there is a general perception that rail passenger services represent a significant financial burden to the federal government and that, of the routes served by the rail system, many are also served by buses which offer service frequency and speed superior to that of the train.

In response to such concerns, the Transportation Development Centre, Transport Canada, initiated a study to identify the most appropriate applications for rail and bus services within the intercity passenger transportation system.

The primary objectives of the study were defined to be as follows:

- To compile objective information on rail and bus costs;
- To develop a methodology by which to compare the relative cost of intercity rail and bus passenger transportation; and
- To determine those conditions under which each of the two modes exhibits the comparative economic advantage with respect to cost performance. The range of conditions to be assessed included traditional buses, high capacity buses and innovative types of bus service which provide an equivalent service to rail in terms of comfort and space.

The Consultant Team selected to carry out the assignment, under the direction of the Transportation Development Centre, Transport Canada, comprised Marshall Macklin Monaghan Limited as prime consultant, assisted by specialists in bus and rail passenger transportation and Travelways Limited.

The study approach, selected by the Consultant Team, consisted of the following major tasks:

- Development of simplified interactive computer models to estimate rail and bus costs.
- The application of these cost models to a range of typical Canadian markets selected jointly by the client and Consultant Team.
- Synthesis of the results and development of findings with respect to **intramodal** and **intermodal** choice.

The findings of the study are presented in this report. The report is structured in the following manner. Chapter 2 addresses the modelling approach and describes the rail and bus cost models. Chapter 3 describes the application of the models to a range of typical Canadian markets and

presents the results with respect to intramodal choice in the context of technological attributes, service attributes, market characteristics and cost performance. Chapter 4 presents a comparison of rail and bus alternatives based on equal passenger flows and the findings with respect to intermodal choice. A summary of the findings is presented in Chapter 5.

This report is augmented by two technical memoranda prepared during the course of the assignment. The first, dated August 8, 1983, is entitled "Model Concepts". The second, dated October 4, 1983, is entitled "Model Development".

2. DESCRIPTION OF THE COST MODELS

The first major task, as identified in the study approach, involved the development of simplified interactive computer models to estimate rail and bus costs. Presented in this chapter is an overview of the modelling approach and a description of both the rail and bus cost models.

2.1 Modelling Approach

Cost modelling can be approached from a number of standpoints. One approach involves starting from first principles. A second approach involves specifying production functions based on economic theories of firm behaviour and then deriving the resulting cost functions. A third approach involves applying statistical averaging techniques based on accounting data. The level of detail that can realistically be achieved with some degree of reliability by any of these approaches depends upon the nature and quality of the available data base.

Since much of the data base related to bus and rail passenger costs is of a proprietary nature and difficult to obtain in other than an aggregate form, particularly in the case of rail services, the basic approach adopted for the development of the cost models involved determining the correlation between a number of key performance variables and cost accounting data.

Ridership, considered to be of importance since it relates to both service frequency and load factor, was treated as an independent variable. Different ridership levels were tested to illustrate how the relative costs of rail and bus vary for different levels of utilization.

2.2 The Rail Cost Model

2.2.1 - The Data Base

As previously mentioned, the general problem of estimating rail costs was compounded by the proprietary nature of the information. Thus, it was necessary to seek alternate data sources.

One of the primary sources identified is a Canadian Transport Commission (C.T.C.) document entitled "A Comparison of AMTRAK and VIA Costing Approaches", dated April 29, 1983. Presented in Table 2.1 is a profile of VIA Rail's operating costs for 1980 and 1981, as reported in the aforementioned report. In addition to a functional breakdown of total annual costs into nine categories, this table also provides an estimate of expenses incurred directly by VIA Rail, and those charged by the railways (CN/CP). For 1980, the total of $456 million consisted of $150 million of VIA's own expenses and $306 million paid to the railways.

2.2.2 - Functional Cost Accounts

These costs include certain interest, amortized capital, depreciation and rental charges. For the purposes of this study, it was necessary to delete

these capital related elements (which will be treated separately later) and to convert the costs to 1983 dollars. Moreover, for convenience, the data was re-arranged into the following four functional categories.

- **Train Operations**, which includes maintenance of rolling stock, crew wages and fuel.
- **Track Related Operations**, which includes maintenance of way, train control and switching, line haul and communication costs.

TABLE 2.1

VIA RAIL COSTS

(million $)

	1980			1981
	VIA	Railways	Total	Total
Train Operations	8.9	116.5	125.4	175.2
Maintenance of Equipment	0.3	122.6	122.9	153.9
Maintenance of Way	-	42.1	42.1	29.3
On-Board Services	-	50.2	50.2	54.5
Station Services	20.4	24.6	45.0	48.0
Marketing and Reservations	15.0	-	15.0	18.3
Taxes and Insurance	1.2	-	1.2	5.2
Depreciation and Amortization	8.1	-	8.1	13.9
General and Administrative	42.5	-	42.5	62.6
Interest	3.3	-	3.3	-
Total	**149.9**	**305.8**	**455.7**	**560.9**

Source: Canadian Transport Commission, A Comparison of AMTRAK and VIA Costing Approaches, April 29, 1983.

In rail costing studies the distinction between train operating and track-related costs is always troublesome. This stems, in part, from conceptual difficulties associated with the "train" and "track" distinction and, in part, from the railways' accounting practices.

In this study, the primary purpose of drawing a distinction between "train operations" and other "track-related costs" was to be able to treat the three major categories that fall under the former separately.

The grouping of the remaining operating cost items together with maintenance of way costs under a loosely-defined category of track related operating costs, was considered to be conceptually consistent.

- **Other Services**, which include on-board and station service costs. Both these functions can generate revenue through charges other than ticket prices. In the case of on-board services, these charges may be on drinks, meals, sleeper service, etc. In the case of station services, revenues can be generated through commercial aspects of station operations (i.e., store rents) to offset costs.

- **Overhead**, which includes marketing, reservations and general administration as the major items.

Presented in Table 2.2 are estimates of rail passenger operating costs for 1980, expressed in terms of 1983 dollars, categorized into the four functional groups. These estimates were based on additional information obtained from the CTC and other published documents.

In 1983 dollars, the total operating cost is estimated to be approximately $590 million exclusive of all rental, depreciation, capital and interest charges. Using VIA Rail's operating statistics for 1980, this figure translates to unit costs of $24.2 per train-kilometre and $3.6 per car-kilometre.

The three major **train operating** costs (ie., equipment maintenance, train crew, and line haul fuel) together account for almost half of the annual operating costs. The track-related operating costs account for 12 percent. On-board and station services together account for 20 percent, while the overhead costs (marketing, reservations, and general administration), constitute the remaining 19 percent.

2.2.3 - Unit Operating Costs by Service

The unit operating costs presented in Table 2.2 represent system wide averages. Factors were derived to convert these system wide estimates to specific unit costs representative of individual types of service (high density, low density and overnight). The specific unit costs by service are presented in Table 2.3. **These unit values constitute the basic operating parameters of the rail passenger cost model.**

TABLE 2.2

VIA PASSENGER RAIL OPERATING COSTS

(1983 $)

	Total Costs Million $	Unit Costs $/train-km	Unit Costs $/car-km	% of Total
Train Operations				
Equipment Maintenance	175.0	7.20	1.07	29.7
Train Crew	75.0	3.09	0.46	12.7
Line Haul Fuel	40.0	1.65	0.25	6.8
	290.0	11.94	1.78	49.2
Track Related Operations	70.0	2.88	0.43	11.8
Other Services				
On-Board Services	70.0	2.88	0.43	11.8
Station Services	50.0	2.06	0.31	8.5
	120.0	4.94	0.74	20.3
Overhead				
Marketing and Reservations	20.0	0.82	0.12	3.4
General Administration	90.0	3.71	0.55	15.3
	110.0	4.53	0.67	18.7
Total	**590.0**	**24.29**	**3.62**	**100.0**

The reasonableness of these estimates was determined, in general terms, by comparing them against other available rail cost data including system wide AMTRAK costs; published costs for specific Canadian corridors including the Windsor-Quebec Corridor; relevant costs obtained from contracts between operators and railway companies; general costs provided by GO Transit; and system wide costs provided by B.C. Railway.(1)

Other data sources also included the published literature and the TDC for estimates of certain capital and maintenance costs and a simulation model developed by the Canadian Institute for Guided Ground Transport (CIGGT) for estimates of energy costs.

TABLE 2.3

PASSENGER RAIL OPERATING COSTS

BY TYPE OF SERVICE

(1983 $)

	Cost Per Car - Kilometre		
	High Density	Low Density	Overnight
Train Operations			
Equipment Maintenance	1.00	2.10	1.20
Train Crew	0.40	1.50	0.40
Line Haul Fuel	0.20	0.30	0.10
Track Related Operations	0.40	0.50	0.30
Other Services			
On-Board Services	0.30	0.30	0.30
Station Services	0.30	0.20	0.70
Overhead			
Marketing and Reservations	0.10	0.10	0.10
General Administration	0.50	1.00	0.60

(1) For further details the reader is directed to Technical Memorandum No. 2, October 4, 1983.

2.2.4 - Unit Operating Costs by Individual Type of Equipment

In the case of rolling stock, it was deemed appropriate to develop alternate unit values and procedures by which to estimate the cost of equipment maintenance, crew costs and fuel costs for individual types of equipment (RDC, LRC and conventional) than to rely solely on system wide averages. These additional values and routines, with which the model has been programmed, are presented in the following paragraphs.

a) Equipment Maintenance

The model is equipped with the following set of default unit values which are representative of the maintenance costs by individual type of equipment:

Conventional	-	$1.70 per locomotive kilometre
	-	$0.90 per coach kilometre
RDC	-	$2.50 per power unit kilometre
	-	$2.00 per additional unit kilometre
LRC	-	$2.25 per locomotive kilometre
	-	$1.15 per coach kilometre

b) Crew Costs

Crew wage costs are very sensitive to work rules, consist configuration, and operating speeds. VIA Rail currently pays its crews according to a distance-based formula which at high operating speeds results in highly inflated wage costs. Crew requirements, on the other hand, are set by consist size. Consists with up to 4 unpowered coaches, for example, require a 3-man crew (engineer, conductor and brake/flagman), while 3 self-powered car consists require a 4-man crew.

Given all these variations, it was deemed appropriate to develop a simple procedure to estimate crew requirements and costs than to rely solely on the system wide average cost.

In fact, the cost model is equipped with two procedures. The first is a "distance based" formula. The second is based on an hourly wage. The user may select from either of these procedures, from the values presented in Table 2.3 or resort to specific independent inputs.

Presented below is the "distance based" formula commonly accepted in the rail industry.

$$Cc = \sum_{i=1}^{n} (a_i x_i) \cdot \frac{f}{y \cdot d \cdot c}$$

where:

Cc	=	annual crew cost per car-kilometre
a_i	=	annual salary of crew member of type i
x_i	=	number of crew members of type i
f	=	fringe, overhead, layover cost factor
y	=	number of working days in a year
d	=	distance that defines a day's work
c	=	number of coaches in the consist

For the purposes of this study, the constant **f** is set to 1.20; the number of working days in a year, **y**, is set to 250; and the distance which defines a working day, **d**, is set at 150 km.

The user may select the size of crew or may resort to the following default values. RDC consists are assigned 2 members. LRC consists are assigned 3 members. Conventional consists are assigned 4 members. The average annual salary per crew member was assumed to be $40 000.00.

The second procedure that can be used for the calculation of crew costs is based on an hourly wage. In this case, the general formula for unit crew costs (Cc) is expressed as follows:

$$Cc = \sum_{i=1}^{n} (w_i x_i) \cdot \frac{f \cdot g}{s}$$

where:

w_i	=	hourly wage of crew member of type i
x_i	=	number of crew members of type i
f	=	fringe, overhead, layover cost factor
g	=	delay, additional dead heading cost factor
s	=	average operating speed

The values which have been adopted are an average hourly wage of $20.00 per hour, an operating speed of 80 km per hour and values of 1.2 and 1.5 for **f** and **g**, respectively. Default crew sizes are the same as those set by the distance based formula.

c) Fuel Costs

Unit fuel costs vary considerably with type of equipment, as well as consist configuration.

Default values with which the program is equipped are listed below:

o	RDC	-	power unit	$0.25 per kilometre
		-	trailing coach	$0.15 per kilometre
o	LRC	-	locomotive	$0.35 per kilometre
		-	trailing coach	$0.02 per kilometre
o	Conventional	-	locomotive	$0.40 per kilometre
		-	coach	$0.05 per kilometre

2.2.5 - Unit Capital Costs

Capital costs of rolling stock, such as locomotives and passenger coaches, are included in the model. Capital costs associated with fixed plant facilities are excluded in order not to bias future rail/bus operating cost comparisons.

Capital costs are annualized by means of the following formula:

$$C_i = CRF_i\,(r, n) \cdot PV_i \cdot NV_i$$

where **C** represents the annual cost of coach or locomotive type i; **PV** represents the price of vehicle type i; **NV** the number of vehicles of that type; and **CRF** the capital recovery factor which is a function of the operating cost of capital r and the vehicle life n.

Even though the model is capable of responding to specific user inputs, it is equipped with the following standard set of default vehicle prices:

	Price $ Millions
RDC Coach	1.0
LRC Locomotive	1.6
LRC Coach	0.6
Conventional Locomotive	1.2
Conventional Coach	0.3

In this study the operating cost of capital is set at five (5) percent per annum over a vehicle life of 15 years.

The annual costs derived by application of the abovementioned equation are converted to unit costs on the basis of utilization rates (ie., vehicle kilometres). These vehicle unit costs can be combined to yield train unit costs for specific consist configurations.

2.2.6 - The Computer Model Framework

Presented in this section of the report is a brief overview of the rail cost model framework.

It is an interactive computer program comprised of four major sections presented in Figure 2.1. A brief description of each is presented below.

- **INPUT**

  This section accepts the route specific input data required by the model. The user is provided with three options.

  Option 1 - the only input requirement is the volume of **car-kilometres.** If this option is selected, then operating costs will be based on the system-wide average unit values presented in Table 2.2.

  Option 2 - the only input requirement is the volume of **car-kilometres by service** (i.e., high density, low density or overnight). If this option is selected, then operating costs will be based on the service specific unit values presented in Table 2.3.

  Option 3 - the input requirements include the type of equipment (LRC, RDC or conventional), the consist configuration, the stage length, daily service frequencies, annual number of service days, seating capacities, annual ridership or average load factors. The program uses these input variables to compute the volume of train-kilometres, locomotive-kilometres, car-kilometres, seat-kilometres and passenger-kilometres.

  If Option 3 is selected, then operating costs for equipment maintenance, crew costs and line haul fuel will be calculated using the detailed formulae and unit values presented in Section 2.2.4.

  Operating costs for track related operations, on board services, station services and overhead will be based on the service specific unit values presented in Table 2.3.

  The program is equipped with significant flexibility. The user can override default variables (i.e., crew wages, etc.) in favour of other preferred input values.

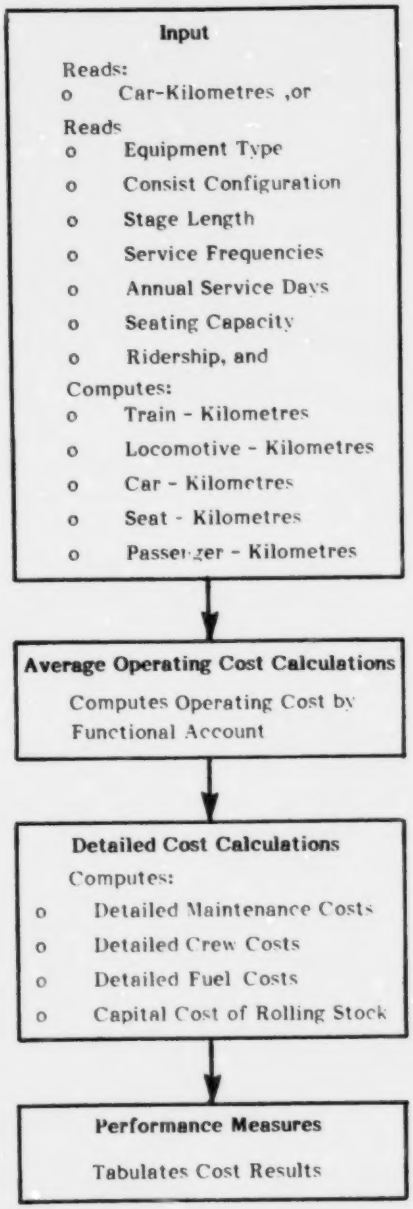
- **AVERAGE OPERATING COST CALCULATIONS**

  This section computes the operating costs by functional category, i.e., equipment maintenance, train crew, fuel, track related costs, on-board services, station services and overhead.

  The computations are based on either the system-wide average unit values presented in Table 2.2 (Option 1) or the service specific unit values presented in Table 2.3 (Option 2).

- **DETAILED COST CALCULATIONS**

  The purpose of this section is to provide refined estimates of the operating costs pertaining to equipment maintenance, crews and fuel and also to introduce estimates of the annualized capital costs of



RAIL COST MODEL FRAMEWORK

Fig. 2.1

rolling stock. The computations are based on the detailed formulae and unit values presented in Section 2.2.4. In calculating crew costs, two options are available, specifically a distance based and an hourly wage formula.

- **PERFORMANCE**

  This section tabulates the costs computed previously and presents the results as a function of the performance measures (i.e., cost per train-kilometre, cost per passenger-kilometre, etc.).

2.3 The Bus Cost Model

2.3.1 - The Model Framework

The bus cost model consists of the four interconnected computer programs illustrated in Figure 2.2. The four programs are each interactive in nature, allowing the user to provide input as required and to modify the specification of the alternative or the flow of the analysis as required.

A brief description of each of the programs is presented below:

- **INPUT**

  This program accepts the route specific input data required by the model and stores the information in computer files. The input data required by the model includes a route schedule, route characteristics (i.e., distances between stops, average speed, etc.), vehicle seating capacity, route ridership and specific driver work rules (i.e., length of a regular shift, overtime pay rate, travel expenses etc.).

  If detailed schedule and demand data is unknown the program will synthesize a schedule and demand pattern based on user supplied aggregate information (i.e., average frequency, average load factor etc.).

- **BUS 1**

  This program uses a simplified algorithm[1] to compute the minimum number of buses required to execute the schedule defined by INPUT.

  It also calculates all vehicle related and passenger related output measures (i.e., vehicle - kilometres, passenger - kilometres etc.) required to compute the route operating costs.

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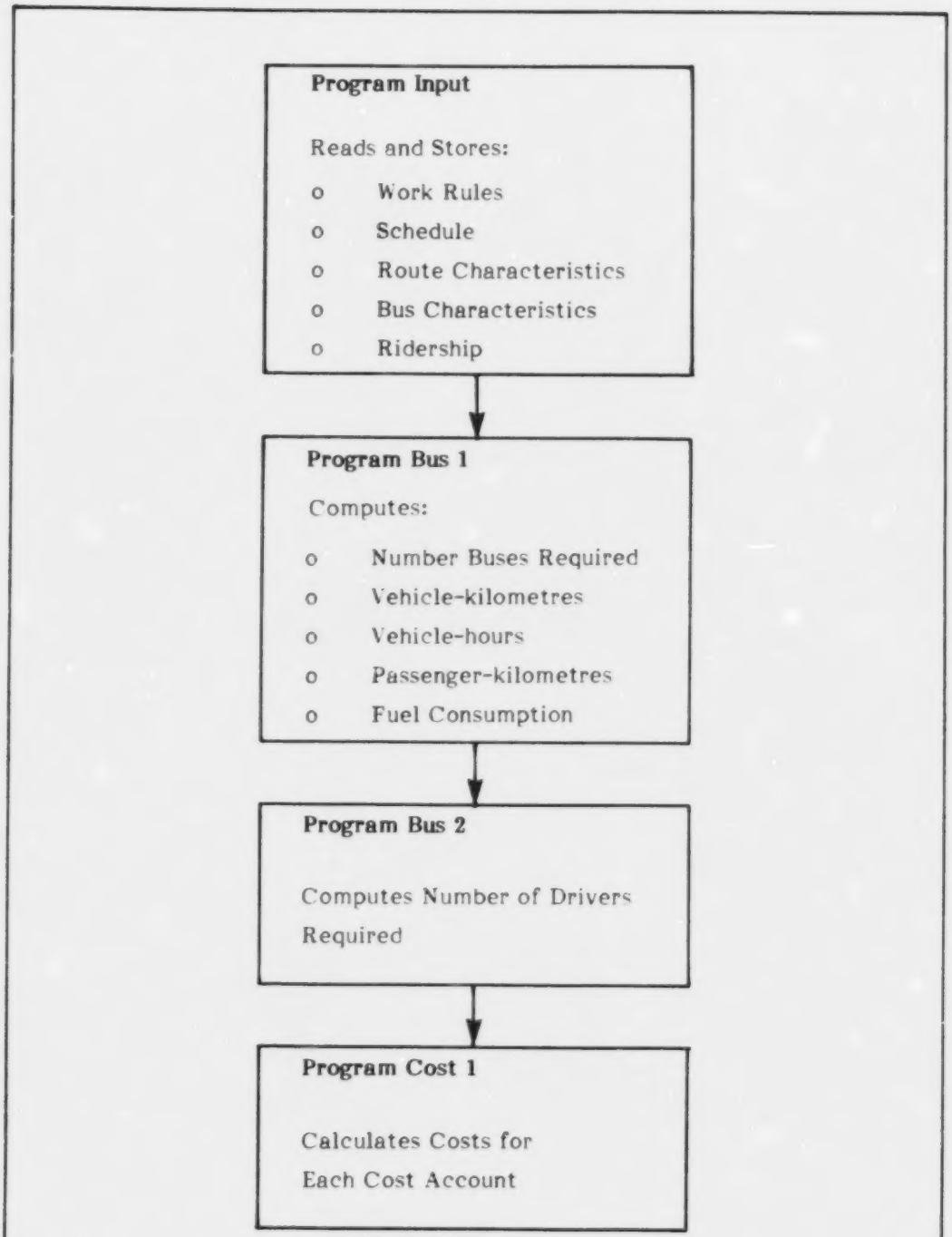
(1) The model makes use of two simplified algorithms to compute the number of buses and drivers required. These algorithms were designed specifically for this project.



BUS COST MODEL FRAMEWORK

Fig. 2.2

- **BUS 2**

  This program estimates the number of drivers required based on the schedule defined by INPUT, the location of stops on route (i.e., transfer points), regular hours in a shift and the location of the driver's home base. Using this estimate, the various driver related cost components (i.e., wages, benefits and expenses) associated with the execution of the schedule defined by INPUT are computed.

- **COST 1**

  This program computes the route costs by cost account and by cost sub-group, given the output measures computed by BUS 1 and BUS 2.

2.3.2 - The Bus Cost Accounts

The Consultant Team's efforts to model bus costs was not nearly as complex a task as in the case of the rail cost model.

Relevant financial information was provided by Travelways Maple Leaf Limited and by the Grey Goose Bus Company. This data was augmented by a fair amount of reasonably successful experience reported in the literature.

Because of these factors, the Consultant Team was able to focus on the specification of the bus cost accounts, associated output measures and on the model framework, in greater detail than was the case for the rail mode. A detailed description of the process is outlined in the two supplementary memoranda.

Presented in Table 2.4 are the unit cost categories and the associated output measures selected for use in the bus cost model. There are six major cost categories. A brief description of each follows:

- **Driver Expenses**, include driver wages, benefits and travel expenses. For a given route's operation these items depend on the number of drivers required daily to meet the route's schedule, the number of hours which these drivers work, the nature and extent of any layovers or deadheading of drivers required by schedule imbalances, and the wage rates for various types of operation (regular shift or overtime). These quantities, in turn, depend upon the route length, schedule, stop locations, and labour agreements concerning work rules, wages, benefits and eligible travel expenses.

- **Vehicle Expenses** include fuel, fuel taxes, operating supplies, depreciation, licenses, insurance, road fees and tolls.

  For a given route's operation, fuel, fuel taxes, operating supplies, licenses and insurance expenses depend on the total vehicle-kilometres travelled (which in turn are a function of the schedule and the route length) and on the relevant unit prices and fuel consumption rates.

TABLE 2.4

BUS UNIT COST CATEGORIES

COST ACCOUNT	OUTPUT UNIT
Driver Expenses	
Driver wages	Driver hours
Driver benefits	% of salaries
Driver travel expenses	Calculated directly
Vehicle Expenses	
Fuel (excluding tax)	Vehicle-kilometres
Fuel taxes	Vehicle-kilometres
Other operating supplies	Vehicle-kilometres
Vehicle fleet depreciation	Vehicles
Vehicle licenses	Vehicle-kilometres
Vehicle insurance	Vehicle-kilometres
Road fees and tolls	Vehicle-kilometres
In-Vehicle Service Expenses	
In-vehicle attendants' wages, benefits, travel expenses	Vehicle-hours
In-vehicle service supplies (food, magazines, etc.)	Passenger-hours
Terminal Expenses	
Ticket costs	Passengers
Agents' commission	Passengers
Terminal operations	Passengers
Maintenance Expenses	
Salaries	Vehicle-kilometres
Benefits	% of salaries
Vehicle repair	Vehicle-kilometres
Repair of in-vehicle service facilities	Vehicle-kilometres
Administrative and General Expenses	
Advertising/Marketing	Vehicle-kilometres
Administration expenses	Vehicle-kilometres

Road fees and tolls are route specific costs which depend on the vehicle-kilometres travelled (i.e., a distance-based road toll).

Depreciation is a function of the type and number of vehicles assigned to the route.

- **In-Vehicle Service Expenses**, include attendant related expenses (i.e., wages and benefits) and service supplies (i.e., food, magazines, etc.). With regards to these items, there is very little experience in the Canadian bus industry.

  Attendant related benefits are dependant on the total number of vehicle-hours of in-vehicle service. Service supply expenses are a function of the number of revenue passenger-hours.

- **Terminal Expenses**, include ticket costs (i.e., the cost of printing the tickets); agent's commission which is the charge levied by the terminal owner on every ticket sold by the operators in the terminal; and all other terminal related expenses (i.e., docking charges) which must be paid by the various operators having access to the terminal. These costs are expressed as a function of the number of revenue passengers carried.

- **Maintenance Expenses**, include salaries and benefits, vehicle repair, and repair of in-vehicle service facilities. These expenses are expressed in terms of the total number of vehicle-kilometres travelled.

- **Administrative and General Expenses** include advertising, marketing and administration.

2.3.3 - The Data Base

Three major sources of data were used to construct the bus cost model:

- Aggregate Class 1 and 2 carrier cost data obtained from Statistics Canada, Passenger Bus and Urban Transit Statistics, Publication No. 53-215, for the years 1974 through 1980 inclusive.

- Grey Goose Bus Co. cost data for the years 1981 to 1983 inclusive, and

- Travelways Maple Leaf Ltd. cost data for their intercity routes for the years 1982 and 1983. These costs were provided for each of Travelways' two major inter-city operating divisions, Lindsay and Kincardine.

These time-series data were used to synthesize best estimates of typical 1983 operating costs by account for a conventional 45-passenger MCI bus.

Comparison of the aggregate Statistics Canada data with the Grey Goose and Travelways data[1] showed a surprising degree of compatibility between the two types of data for many of the cost accounts. Figure 2.3 provides examples of two such accounts, in which it is seen that when the two types of data are plotted by year of operation they produce a very smooth trend curve. These results imply that Grey Goose in particular is a very "typical" bus operator and that the aggregate Statistics Canada statistics are more useful than one might have initially supposed.

While not all cost accounts exhibited the same degree of regularity displayed in Figure 2.3, it proved possible to estimate a typical 1983 unit cost for the accounts requiring such unit rates by fitting smooth curves through the Statistics Canada, Grey Goose and Travelways data and then reading the unit rates for 1983 from these curves. The only major exceptions to this procedure involved driver wages, driver benefits and maintenance personnel benefits. In all cases, the Grey Goose and Travelways rates appear to be significantly different from the national average, and in all three cases the 1983 estimates are based solely on extrapolations of the Statistics Canada data.

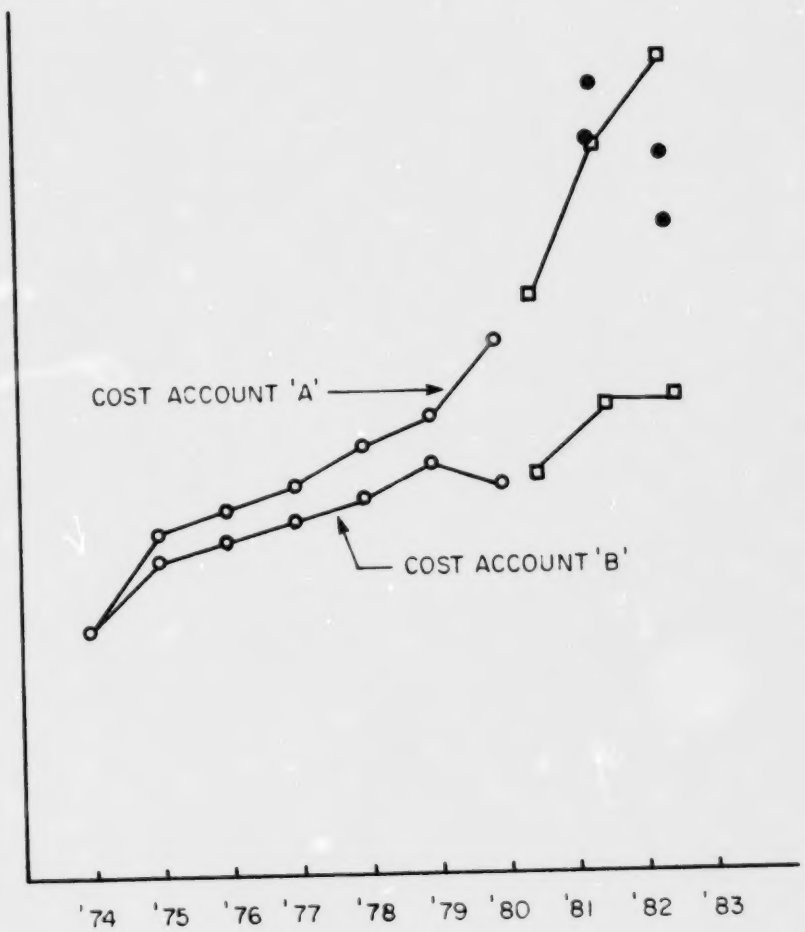
2.3.4 - Unit Costs for Conventional Buses

Table 2.5 presents the 1983 unit cost estimates for **a conventional 45-passenger MCI bus,** categorized as elements of the six major cost accounts. **These values constitute the basic parameters of the bus passenger cost model.**

In-vehicle service expenses are non relevant in the case of the conventional MCI bus. Accordingly, they are defined as such. The I's in the table indicate rates which are calculated internally within the cost model as a function of more fundamental user-supplied data. For example, the vehicle fleet depreciation rate is a function of the capital cost of the vehicle, the vehicle's economic life, and the interest rate which for the purpose of this study are set at the following values:

o	Capital cost of an MCI vehicle	$ 200 000.00
o	Vehicle life	10 Years
o	Annual Cost of Capital	5 percent
o	Vehicle salvage value	$ 500.00

(1) In order to protect the confidentiality of the Grey Goose and Travelways data, the discussion of this synthesis process is presented in quite generalized terms, and the only numbers actually shown are the final synthesized 1983 unit costs which do not correspond precisely to "real" Grey Goose or Travelways costs.



EXAMPLES OF BUS UNIT COST TRENDS

Fig. 2.3

TABLE 2.5

ESTIMATED 1983 BUS UNIT COSTS FOR

A CONVENTIONAL 45 PASSENGER MCI BUS

COST ACCOUNT	UNIT COST*	OUTPUT UNIT
Driver Expenses		
Driver Wages	I	Driver hours
Driver Benefits	20.8%	% of salaries
Driver Travel Expenses	I	Calculated directly
Vehicle Expenses		
Fuel (including tax)	14.0	Vehicle-kilometres
Other Operating Supplies	2.9	Vehicle-kilometres
Vehicle Fleet Depreciation	I	Vehicles
Vehicle Licenses	0.6	Vehicle-kilometres
Vehicle Insurance	1.1	Vehicle-kilometres
Road Fees and Tolls	0.5	Vehicle-kilometres
In-Vehicle Service Expenses		
In-Vehicle Attendants' Wages, Benefits, Travel Expenses	N/A	Vehicle-hours
In-Vehicle Service Supplies (Food, Magazines, etc.)	N/A	Passenger-hours
Terminal Expenses		
Ticket Costs	9.6	Passengers
Agents' Commission	75.2	Passengers
Terminal Operations	81.8	Passengers
Maintenance Expenses		
Salaries	8.9	Vehicle-kilometres
Benefits	20.8%	% of salaries
Vehicle Repair	15.4	Vehicle-kilometres
Repair of In-Vehicle Service Facilities	N/A	Vehicle-kilometres
Administrative & General Expenses		
Advertising/Marketing	2.8	Vehicle-kilometres
Administration Expenses	14.2	Vehicle-kilometres

Legend:
I: Internally calculated within the model
N/A: Not applicable
* Cents per unit output, except for benefits

2.3.5 - Unit Costs for Non-conventional Bus Scenarios

Six alternate bus scenarios were considered in this investigation. They are presented below categorized as either conventional technology; conventional buses with innovative attributes which provide an equivalent service to rail in terms of comfort, space and on-board services; high capacity buses and technological alternatives to the conventional bus which are considered feasible in the short term.

Category	Scenario
o Conventional Bus	o 40' Bus, 45 Seats
o Conventional Buses with Innovative On-Board Attributes	o 40' Bus, 30 Seats o 40' Bus, 22 Seats On Board Attendant On Board Meal Service
o High Capacity Buses and Technological Alternatives	o 40' Bus, 45 Seats Improved Fuel Efficiency o 45' Bus, 53 Seats Improved Fuel Efficiency o High Capacity Bus, 75 Seats

The conventional bus is twelve metres long (40 feet) and seats 45 passengers. On-board service alternatives considered by this investigation include the conventional bus with a reduced capacity of 30 seats and the conventional bus with a reduced capacity of 22 seats plus on-board attendant and meal service.

Technological alternatives to the conventional bus which are considered feasible and have been included in this study are a bus of the same size and seating capacity equipped with an improved fuel efficient engine; a slightly larger bus (45 feet) with a capacity of 53 seats equipped with a fuel efficient engine; and a high capacity bus (either articulated or double decker) with approximately 75 seats.

Operational experience, in Canada, with respect to such non-conventional buses and in-service attributes is extremely limited and very little reliable cost data is available for such buses. Accordingly, it was again necessary to seek the required information from secondary sources.

Some of the most reasonable estimates of such costs come from studies of non-conventional bus technology **feasibility** rather than from actual operating experience. In particular, the N.D. Lea study for Transport Canada, "A Feasibility Study of the Introduction of Larger Capacity Intercity Buses" April, 1979 and a recent UTDC proposal to the

Transportation Development Centre, "A Proposal for Development of a High Capacity, Fuel Efficient Intercity Bus" provide a very reasonable spread in cost estimates for such vehicles. The N.D. Lea estimates represent a fairly conservative or upper bound cost scenario and the more recent UTDC proposal represents a more optimistic or lower bound case.

The N.D. Lea estimates are based on existing technology (i.e., Neoplan buses), a survey of operating experience (primarily European) and judgements concerning how this experience would translate into a Canadian operational setting. Limited demonstration tests, in Canada, of a double-deck bus by Pacific Coach Lines and an articulated bus by Voyageur-Colonial have provided somewhat ambiguous results in that they have not conclusively confirmed or rejected the N.D. Lea estimates. In light of this, the Consultant Team deemed that these estimates still appeared to be reasonable measures of what a properly implemented, full-scale non-conventional intercity bus operation might cost using currently available technology.

Other data concerning the operating costs and fuel consumption of high capacity buses was obtained through discussions with representatives of the Ontario Ministry of Transportation and Communications, responsible for monitoring the Province's urban area articulated bus pilot project.

Presented in Table 2.6 are the factors selected to convert the conventional MCI bus unit cost accounts (presented in Table 2.5) to specific unit costs representative of the individual types of service and technology for each of the scenarios under study. Cost components whch are affected include:

- **Drivers' Wages** - these are assumed to be 10 percent higher for drivers of high capacity vehicles.

- **Fuel** - the consumption rate of a fuel efficient vehicle is assumed to be 40 percent lower than that of a conventional bus. The consumption rate of a high capacity vehicle is assumed to be 30 percent higher than a conventional bus.

- **Operating Supplies** - assumed to be 40 percent higher in the case of high capacity vehicles.

- **License** - assumed to be 10 percent higher in the case of a 53 seat vehicle and 40 percent higher in the case of a high capacity (75 seat) vehicle.

- **Insurance** - assumed to be a function of the vehicle size. The insurance expense is assumed to be 10 percent higher in the case of a 53 seat vehicle and twice the cost of a conventional bus in the case of a high capacity vehicle.

- **Maintenance** - is assumed to be 40 percent higher in the case of a high capacity vehicle.

- **Capital Costs** - these are assumed to be 5 percent higher in the case of on-board meal service to account for the additional equipment required (ie., galley); 5 percent higher in the case of the improved fuel efficient engine; 10 percent higher in the case of a 53 seat bus (ie., larger vehicle) with improved fuel efficient engine; and 60 percent higher in the case of high capacity vehicles.

- **On-Board Attendant Wages** - assumed to be $10 per hour.

- **Food/Beverage** - assumed to be $0.50 per passenger-hour.

These assumptions form the basis for this analysis of bus alternatives.

TABLE 2.6

ESTIMATED CHANGES IN BUS UNIT COSTS
FOR NON-CONVENTIONAL BUSES

	SCENARIO					
	Conv. 40' Bus	Conventional 40' Bus with Service Alternatives		Technological Alternatives		
	45 Seats	30 Seats	22 Seats Att./Meals	40' Bus 45 Seats Inc. Fuel Efficiency	45' Bus 53 Seats Inc. Fuel Efficiency	High Capacity Bus 75 Seats
COST ACCOUNT						
Wages - Driver	o	o	o	o	o	+ 10%
- Attendant	-	-	$10/veh-hr	-	-	-
Fuel	o	o	o	- 40%	- 40%	+ 30%
Op. Supplies	o	o	o	o	o	+ 40%
Food/Beverage	-	-	$0.50/pass-hr	-	-	-
License	o	o	o	o	+ 10%	+ 40%
Insurance	o	o	o	o	+ 10%	+ 100%
Maintenance						
- Salaries	o	o	o	o	o	+ 40%
- Supplies	o	o	o	o	o	+ 40%
Capital Cost	o	o	+ 5%	+ 5%	+ 10%	+ 60%

Legend - Not applicable o Base case or no change from base

3. APPLICATION OF THE COST MODELS

The second major task, as identified in the study approach, involved application of the rail and bus cost models to a range of typical Canadian markets, selected jointly by the client and Consultant Team. Presented in Section 3.1 of t. .s chapter are the intercity routes selected for study. In Sections 3.2 and 3.3, the rail and bus cost models are applied individually to the selected routes on the basis of existing mode specific service frequencies and passenger flows and a comparison of the "within mode" advantages is carried out.

In Chapter 4, the models are applied on the basis of equal passenger flows thus providing opportunity for a comparison of cost performance "between modes" not only in terms of unit costs but also in terms of total costs.

3.1 Intercity Routes Selected For Study

Seven intercity routes were selected for study. They include one link in the Atlantic Region, two in the Quebec City - Windsor corridor and four western routes. The seven routes are identified below, categorized as a function of stage length as either a short, medium or long haul run and as a function of the existing volume of passenger travel on the link as being of either low or high density.

Link	Region	Description
Montreal-Ottawa	Corridor	Short Haul - High Density
Regina - Saskatoon	Western	Short Haul - Low Density
Sydney - Halifax	Atlantic	Medium Haul - Low Density
Toronto - Montreal	Corridor	Medium Haul - High Density
North Vancouver - Prince George	Western	Long Haul - Low Density
Winnipeg - Thompson	Western	Long Haul - Low Density
Winnipeg - Edmonton	Western	Long Haul - Low Density

3.2 Application of the Rail Cost Model

3.2.1 - Rail Service on the Selected Links

Presented in Table 3.1 is a summary of the existing passenger rail service on the selected links. The service attributes include the stage length; the one-way travel time, ranging from 129 minutes (2.15 hours) on the shortest route to 1 735 minutes (28.9 hours) on the longest; and the frequency of service based on the most current schedule of operations at the time of study. Daily frequencies vary from a one-way trip per day on several long haul routes (i.e., North Vancouver - Prince George or Winnipeg - Thompson) to twelve, one-way trips per day on high density routes (i.e., Montreal - Ottawa, Toronto - Montreal).

Direct rail service between Winnipeg and Edmonton was discontinued in the late seventies. Currently, passengers transfer trains in Saskatoon. The service frequency presented in Table 3.1 is based on the lower value exhibited by either of the two.

TABLE 3.1
EXISTING PASSENGER RAIL SERVICE ON THE STUDY ROUTES

	City Pair	Dist. (km)	Travel Time (min.)	Frequency Mon.	Tu.	We.	Th.	Fr.	Sat.	Sun.	Service
1.	Montreal - Ottawa			6	6	6	6	6	6	5	
	Ottawa - Montreal			6	6	6	6	6	6	4	
	Total	187	129	12	12	12	12	12	12	9	High Density
2.	Regina - Saskatoon			1	1	1	1	1	1	1	
	Saskatoon - Regina			1	1	1	1	1	1	1	
	Total	263	235	2	2	2	2	2	2	2	Low Density
3.	Sydney - Halifax			2	2	2	2	2	2	2	
	Halifax - Sydney			2	2	2	2	2	2	2	
	Total	473	434	4	4	4	4	4	4	4	Low Density
4.	Toronto - Montreal			6	6	6	6	6	5	5	
	Montreal - Toronto			6	6	6	6	6	5	5	
	Total	539	317	12	12	12	12	12	10	10	High Density
5.	N. Vancouver - P. George			0	0	1	0	1	0	1	
	P. George - N. Vancouver			1	0	0	1	0	1	0	
	Total	744	780	1	0	1	1	1	1	1	Low Density
6.	Winnipeg - Thompson			0	1	0	1	0	1	0	
	Thompson - Winnipeg			0	0	1	0	1	0	1	
	Total	1 149	1 318	0	1	1	1	1	1	1	Overniter
7.	Winnipeg - Edmonton			1	1	1	1	1	1	1	
	Edmonton - Winnipeg			1	1	1	1	1	1	1	
	Total	1 357	1 735	2	2	2	2	2	2	2	Overniter

3.2.2 - Rail Passenger Flow Volumes

Shown in Table 3.2 are estimates of current passenger travel, by rail, between the major centres of study. These estimates are expressed in terms of annual, two-way passenger flow volumes. Also shown are the criteria upon which the figures are based. Of the seven estimates, four are based on origin-destination (O-D) travel volumes reported by others. Since such information was not available for the remaining three links (Regina - Saskatoon, North Vancouver - Prince George and Winnipeg - Thompson), the Consultant Team, in consultation with the Transportation Development Centre, developed representative figures using secondary data sources as outlined in the table.

The link volumes vary from a minimum of 5 000 person trips per annum on the North Vancouver - Prince George and Winnipeg - Thompson services to a maximum of 480 000 annual person trips on the Toronto - Montreal service.

3.2.3 - Route Specific Rail Scenarios

A total of sixteen alternate rail scenarios were selected for study. They are listed in Table 3.3 as scenarios R1 to R16.

The scenarios differ from one another according to the type of rail equipment, the consist configuration and the frequency of service.

Presented below is a brief description of each of these parameters.

- **Type of Equipment**

  - On high density runs (i.e., Montreal - Ottawa and Toronto - Montreal) the alternatives include LRC, RDC and conventional rail equipment. On low density runs the alternatives are limited to either RDC or conventional equipment.

- **Consist Configuration**

  - The consist configuration is dependant upon the type of equipment under consideration, the volume of passenger traffic and the stage length. The range of on-board services considered in this study include on-board meal service (i.e, dinettes and modified snack bars) and sleeping accommodation on the overnight hauls.

    Also, presented in Table 3.3 are the respective number of cars per train and number of seats per train for the selected consist configuration. The number of cars per train ranges from a

TABLE 3.2
REPRESENTATIVE ANNUAL, RAIL PASSENGER FLOW VOLUMES

	City - Pair	2-Way Travel	Basis of Selection
1.	Montreal - Ottawa	200 000	o Reported 1977 O-D of 188 000 ("Via Rail Canada - an analysis of Via's potential in fulfilling rail passenger policy objectives", A.M. Khan, 1980).
2.	Regina - Saskatoon	7 500	o Estimate developed using TDC reported bus O-D and adjusting for relative rail/bus frequency (1:6).
3.	Sydney - Halifax	15 000	o Reported 1980 O-D of 11 100 ("Maritime Provinces Intermodal Passenger Study - Part 1", Transport Canada, 1983)
4.	Toronto - Montreal	480 000	o Reported 1977 of 458 000 ("Via Rail Canada - an analysis of Via's potential in fulfilling rail passenger policy objectives", A.M. Khan, 1980).
5.	N. Vancouver - P. George	5 000	o Estimate based on 1982 system ridership of 71 400 by B.C. Railway and by assuming approximately 30% to be the traffic component on the route and by adjusting for avg. trip length which is approximately 25% of the route length.
6.	Winnipeg - Thompson	5 000	o Estimate developed using Grey Goose reported bus O-D and adjusting for relative rail/bus frequency (1:3) and relative travel time (2:1).
7.	Winnipeg - Edmonton	25 000	o Reported 1979 O-D of 23 168, prior to discontinuation of direct service. (TDC/Via Western Intercity Study).

TABLE 3.3
ROUTE SPECIFIC RAIL SCENARIOS

	City - Pair	Scenario	Annual O-D	Daily Freq. (2-way)	Equipment and Consist (Typical)	Cars Per Train	Seats Per Train
1.	Montreal - Ottawa	R 1	200 000	12	LRC: 1PV + 3C + 1CL	5	280
		R 2	200 000	12	CONV: 1PV + 2C + 1CL + 1D	5	189
		R 3	200 000	12	RDC: RDC + MSB	2	124
2.	Regina - Saskatoon	R 4	7 500	2	RDC: RDC	1	77
		R 5	7 500	4	RDC: RDC	1	77
3.	Sydney - Halifax	R 6	15 000	2	RDC: RDC	1	77
		R 7	15 000	4	RDC: RDC	1	77
		R 8	15 000	2	RDC: RDC + MSB	2	124
		R 9	15 000	4	RDC: RDC + MSB	2	124
4.	Toronto - Montreal	R10	480 000	12	LRC: 1PV + 4C + 1CL	6	354
		R11	480 000	12	CONV: 2PV + 3C + 1CL + 1DN + 1	8	320
5.	N. Vancouver - P. George	R12	5 000	2	CONV: 1PV + 1C + 1CL + 1	4	108
		R13	5 000	2	RDC: RDC + MSB	2	124
6.	Winnipeg - Thompson	R14	5 000	2	CONV: 1PV + 2C + 2S + 1CL + 2D + 1	9	228
		R15	5 000	2	CONV: 1 PV + 1C + 1CL + 1	4	108
7.	Winnipeg - Edmonton	R16	25 000	2	CONV: 3PV + 3C + 2DN + 6S + 4	18	416

Legend

PV - Power Unit C - Coach CL - Club Car DN - Dayniter D - Dinette MSB - Modified Snack Bar
S - Sleeper

minimum of 1 RDC (77 seats) on the Regina - Saskatoon run to a maximum of 18 cars (416 seats) on the Winnipeg - Edmonton overnight run[1] consisting of three power units, three coaches, two dayniters, six sleepers and four others (i.e., baggage etc.).

- **Frequency of Service**

  - In general, scenarios are assigned the respective weekday scheduled service frequency as defined in Table 3.1. On the North Vancouver - Prince George and Winnipeg - Thompson routes, the basic service frequency is increased to two trips per day (one each way) to facilitate the use of the rail cost model. On the Regina - Saskatoon and Sydney - Halifax routes, alternatives to the basic scheduled service frequency are also examined.

3.2.4 - Annual Rail Operations

Presented in Table 3.4 is a summary of annual operations by rail scenario.

The performance measures include:

- Annual Train - Kilometres,
- Annual Locomotive - Kilometres
- Annual Car - Kilometres
- Annual Seat - Kilometres

- Annual Passenger - Kilometres
- Average Number of Passengers per Train, based on the ratio of annual passenger - kilometres to annual train - kilometres, and
- Average Load Factor, based on the ratio of annual passenger - kilometres to annual seat - kilometres

The performance measures are calculated using a weekend/weekday ratio of 0.75 which yields the equivalent of 339 service days per year.

The scenarios cover a broad spectrum of passenger rail operations. Annual train - kilometers range from a minimum of 178 000 on the Regina - Saskatoon run (Scenario R4) to a maximum of 2 193 000 on the Toronto - Montreal route (Scenarios R10 and R11). Annual car - kilometres vary between 178 000 (Scenario R4) and 17 831 000 (Scenario R16, Winnipeg - Edmonton). Anual passenger - kilometres vary between 1 972 000 (Scenarios R4 and R5) and 258 720 000 (Scenarios R10 and R11).

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(1) For the purposes of this study it is assumed that direct overnight rail service exists between Winnipeg and Edmonton.

TABLE 3.4
SUMMARY OF ANNUAL RAIL OPERATIONS

	Link	Scenario	Equip.	Train -Km (000's)	Loc. -Km (000's)	Car -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Passengers Per Train	Load Factor (%)
1.	Montreal - Ottawa	R1	LRC	761	761	3 804	213 000	37 400	49	17.6
		R2	CONV.	761	761	3 804	143 775	37 400	49	26.0
		R3	RDC	761	761	1 521	94 329	37 400	49	39.6
2.	Regina - Saskatoon	R4	RDC	178	178	178	13 730	1 972	11	14.4
		R5	RDC	357	357	357	27 460	1 972	6	7.2
3.	Sydney - Halifax	R6	RDC	321	321	321	24 693	7 095	22	28.7
		R7	RDC	641	641	641	49 387	7 095	11	14.4
		R8	RDC	321	321	641	39 766	7 095	22	17.8
		R9	RDC	641	641	1 283	79 532	7 095	11	8.9
4.	Toronto - Montreal	R10	LRC	2 193	2 193	13 156	778 391	258 720	118	33.2
		R11	CONV.	2 193	4 385	17 541	701 649	258 720	118	36.9
5.	N. Vancouver - P. George	R12	CONV.	504	504	2 018	54 479	3 720	7	6.8
		R13	RDC	504	504	1 009	62 550	3 720	7	5.9
6.	Winnipeg - Thompson	R14	CONV.	779	779	7 011	179 175	5 745	7	3.2
		R15	CONV.	779	779	7 011	84 134	5 745	7	6.8
7.	Winnipeg - Edmonton	R16	CONV.	991	2 972	17 831	414 075	33 925	34	8.2

Passenger rail load factors range between 3.2 and 39.6 percent. The lowest values are exhibited on the three long haul routes, specifically North Vancouver - Prince George, Winnipeg - Thompson and Winnipeg -Edmonton.

The highest values are exhibited on the two high-density runs specifically Montreal - Ottawa and Toronto - Montreal.

3.2.5 - Annual Operating Costs

The rail cost model was applied to each of the sixteen scenarios, using:

- The unit capital costs presented in Section 2.2.5;
- The basic unit values for equipment maintenance and line haul fuel, presented in Section 2.2.4;
- The "distance based" formula for crew costs, presented in Section 2.2.4; and
- The basic unit costs for track related operations, on-board services, station services, and overhead presented in Table 2.3.

Exhibited in Table 3.5 are the results expressed in terms of annual operating costs and in terms of unit operating costs per train - kilometre, per car - kilometre, per seat - kilometre and per passenger - kilometre.

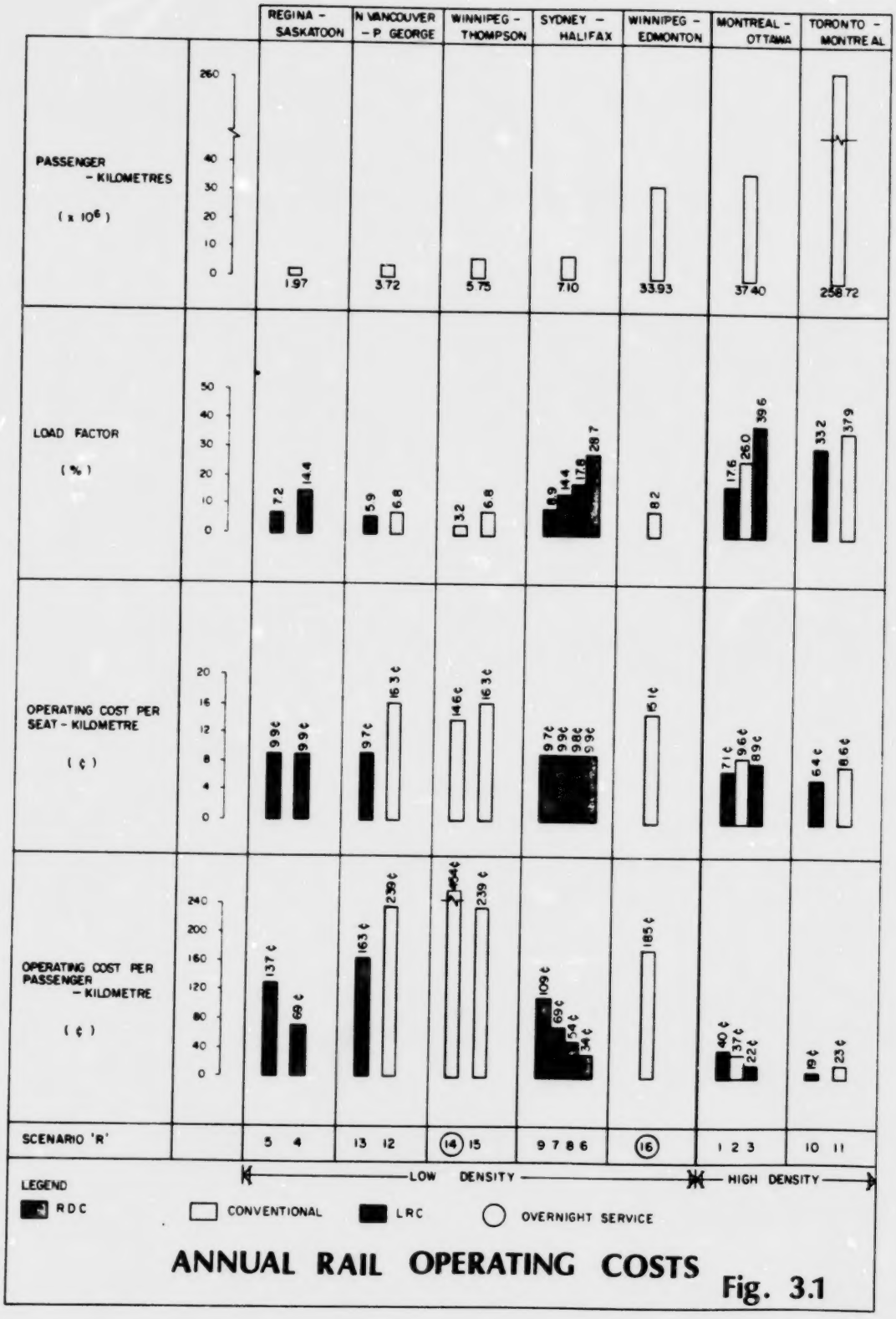
A strict comparison of the equipment specific costs cannot be undertaken since these costs are based on preselected consist configurations. For example, two dayniters and six sleepers were included in the rail consist configuration (Scenario R16) operating between Winnipeg and Edmonton. Had these components been excluded (in favour of an alternate consist configuration featuring sufficient capacity), then the resulting costs would differ from those presented.

A general comparison of the equipment specific costs is presented below in terms of the cost per seat-kilometre (i.e., implicitly assumes a load factor equal to 100 percent). A similar comparison, in terms of the cost per passenger-kilometre (i.e., varying load factors), is presented graphically in Figure 3.1.

	Cents Per Seat-Kilometre		
	Low Density	High Density	Overnight
Conventional	16.3	8.6 -9.6	14.6 -15.1
RDC	9.7 - 9.9	8.9	N/A
LRC	N/A	6.4 -7.1	N/A

TABLE 3.5
PASSENGER RAIL OPERATING COSTS

Link	Seen.	Equip.	Annual Operating Costs $ Millions	$ Per Train -Km	$ Per Car -Km	¢ Per Seat -Km	¢ Per Pass. -Km
1. Montreal - Ottawa	R1	LRC	15.13	19.88	3.98	7.1	40
	R2	CONV.	13.85	18.20	3.64	9.6	37
	R3	RDC	8.40	11.04	5.52	8.9	22
2. Regina - Saskatoon	R4	RDC	1.36	7.64	7.64	9.9	69
	R5	RDC	2.71	7.59	7.59	9.9	137
3. Sydney - Halifax	R6	RDC	2.44	7.60	7.60	9.9	34
	R7	RDC	4.88	7.61	7.61	9.9	69
	R8	RDC	3.86	12.02	6.02	9.8	54
	R9	RDC	7.73	12.06	6.02	9.7	109
4. Toronto - Montreal	R10	LRC	49.94	22.77	3.80	6.4	19
	R11	CONV.	59.97	27.35	3.42	8.6	23
5. N. Vancouver - P. George	R12	CONV.	8.88	17.62	4.40	16.3	239
	R13	RDC	6.08	12.06	6.03	9.7	163
6. Winnipeg - Thompson	R14	CONV.	26.11	33.52	3.72	14.6	454
	R15	CONV.	13.71	17.60	4.40	16.3	239
7. Winnipeg - Edmonton	R16	CONV.	62.64	63.21	3.51	15.1	185



ANNUAL RAIL OPERATING COSTS

Fig. 3.1

Of the three types of equipment considered, LRC's operating on the high density routes (i.e., Montreal-Ottawa and Toronto-Montreal) exhibit the lowest operating costs. This is not unusual since LRC's are designed to operate on such high density, short haul routes where relatively high operating speeds are required, yet where the routes are short enough that sleeping accommodations are not needed.

RDC's exhibit the lowest operating costs on the low density routes (which in the case of this investigation, are defined by passenger flow levels ranging between 1.97 and 7.10 million passenger-kilometres). Again, this result conforms to the design and current use of such equipment, i.e., on low density routes where small consists are required and where the operation of conventional rail (single unit and coach) cannot be justified.

On overnight routes, conventional rail, featuring dayniters and sleepers, exhibit operating costs ranging between 14.6 and 15.1 cents per seat-kilometre.

The reader is again reminded that these results originally stem from the system-wide average unit values (for VIA operations) presented in Table 2.2 and they include various cost elements which may be deemed slightly excessive (i.e., crew wages, maintenance charged by the railways). If these items were excluded or trimmed, the resulting costs would differ from these presented.

To this point the results are based on representative O-D travel volumes between the major centres. Presented on the following two tables (Tables 3.6 and 3.7) is a comparison of operating costs by equipment type (RDC, conventional, LRC) as a function of load factor.

This segment of the analysis focuses on the following three representative routes Regina-Saskatoon, Winnipeg-Edmonton and Montreal-Ottawa. The load factors tested range from 20 to 100 percent. The results, per passenger-kilometre are also presented graphically in Figure 3.2.

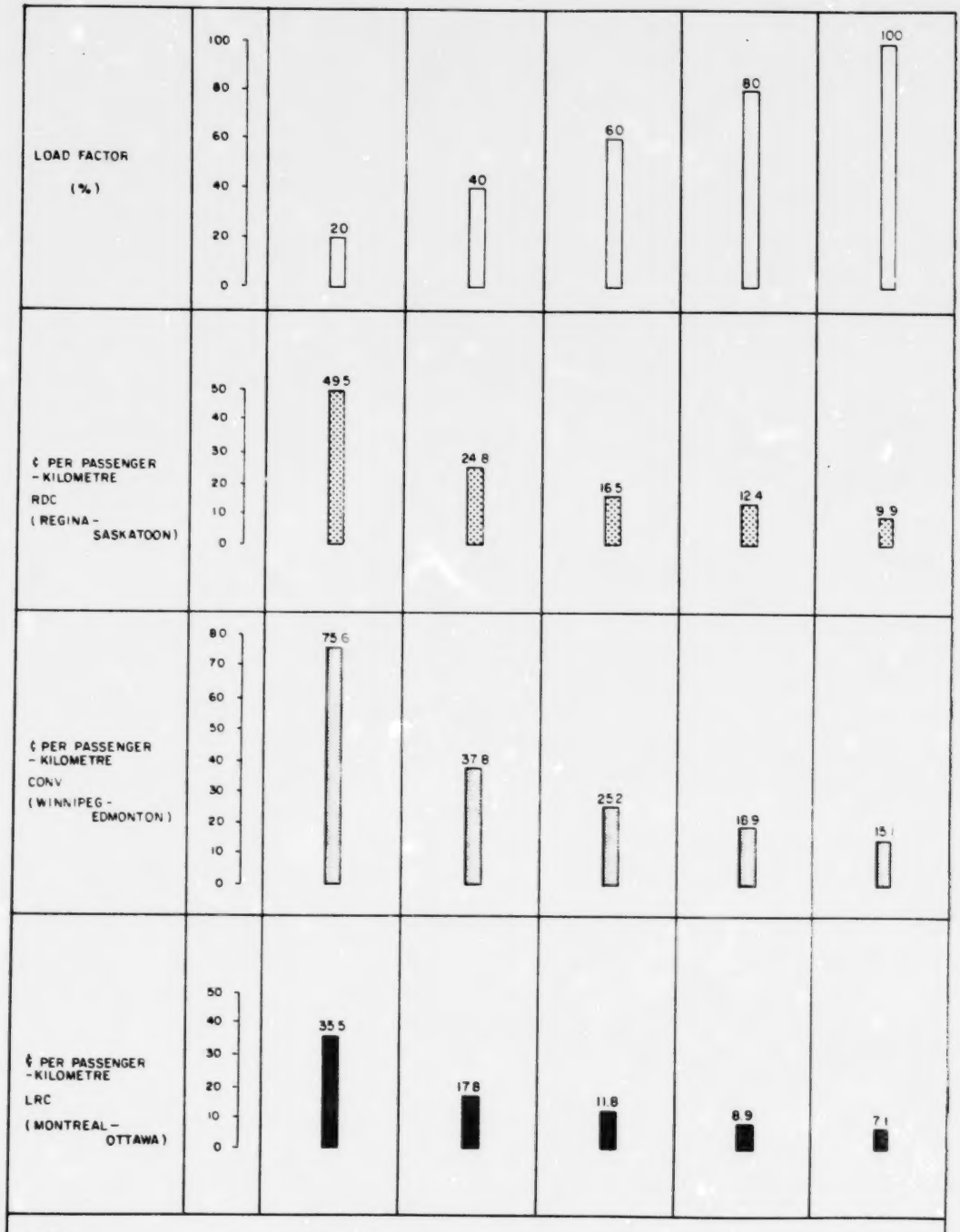
3.2.6 - Detailed Cost Analysis

Presented in Table 3.8 are detailed costs by cost account for each combination of service and rolling stock considered;

RDC
- o Low density
- o Low density including modified snack bar
- o High density including modified snack bar

Conventional
- o Low density
- o Low density overniter
- o High density

LRC
- o High density



COMPARISION OF RAIL OPERATING COSTS

AT EQUAL LOAD FACTORS

Fig. 3.2

TABLE 3.6

OPERATIONS AT VARYING LOAD FACTORS

Link	Scenario	Daily Freq. (2-Way)	Equipment	Seats Per Train	Train km (000's)	Seat km (000's)	Load Factor (%)	Ridership	Pass. km (000's)	Pass. Per Train
Regina-Saskatoon	R4	2	IRDC	77	178	13 730	14.4	7 500	1 972	11
Regina-Saskatoon	R4a	2	IRDC	77	178	13 730	20.0	10 441	2 746	15
Regina-Saskatoon	R4b	2	IRDC	77	178	13 730	40.0	20 882	5 492	31
Regina-Saskatoon	R4c	2	IRDC	77	178	13 730	60.0	31 323	8 238	46
Regina-Saskatoon	R4d	2	IRDC	77	178	13 730	80.0	41 764	10 984	62
Regina-Saskatoon	R4e	2	IRDC	77	178	13 730	100.0	52 205	13 730	77
Winnipeg-Edmonton	R16	2	CONV: 3PV+3C +2DN+GS+4	416	991	414 075	8.2	25 000	33 925	34
Winnipeg-Edmonton	R16a	2	CONV: 3PV+3C +2DN+GS+4	416	991	414 075	20.0	61 028	82 815	84
Winnipeg-Edmonton	R16b	2	CONV: 3PV+3C +2DN+GS+4	416	991	414 075	40.0	122 056	165 630	167
Winnipeg-Edmonton	R16c	2	CONV: 3PV+3C +2DN+GS+4	416	991	414 075	60.0	183 084	248 445	251
Winnipeg-Edmonton	R16d	2	CONV: 3PV+3C +2DN+GS+4	416	991	414 075	80.0	244 112	331 260	334
Winnipeg-Edmonton	R16e	2	CONV: 3PV+3C +2DN+GS+4	416	991	414 075	100.0	305 140	414 075	416
Montreal-Ottawa	R1	12	LRC: 1PV+3C+1CL	280	761	213 000	17.6	200 000	36 400	49
Montreal-Ottawa	R1a	12	LRC: 1PV+3C+1CL	280	761	213 000	20.0	227 807	42 600	56
Montreal-Ottawa	R1b	12	LRC: 1PV+3C+1CL	280	761	213 000	40.0	455 615	85 200	112
Montreal-Ottawa	R1c	12	LRC: 1PV+3C+1CL	280	761	213 000	60.0	683 422	127 800	168
Montreal-Ottawa	R1d	12	LRC: 1PV+3C+1CL	280	761	213 000	80.0	911 230	170 400	224
Montreal-Ottawa	R1e	12	LRC: 1PV+3C+1CL	280	761	213 000	100.0	1 139 037	213 000	280

TABLE 3.7

OPERATING COSTS AT VARYING LOAD FACTORS

Link	Scenario	Equipment	$Millions	¢ Per Seat-km	¢Per Pass.-km
Regina-Saskatoon	R4	RDC	1.36	9.9	69.0
Regina-Saskatoon	R4a	RDC	1.36	9.9	49.5
Regina-Saskatoon	R4b	RDC	1.36	9.9	24.8
Regina-Saskatoon	R4c	RDC	1.36	9.9	16.5
Regina-Saskatoon	R4d	RDC	1.36	9.9	12.4
Regina-Saskatoon	R4e	RDC	1.36	9.9	9.9
Winnipeg-Edmonton	R16	CONV.	62.64	15.1	185.0
Winnipeg-Edmonton	R16a	CONV.	62.64	15.1	75.6
Winnipeg-Edmonton	R16b	CONV.	62.64	15.1	37.8
Winnipeg-Edmonton	R16c	CONV.	62.64	15.1	25.2
Winnipeg-Edmonton	R16d	CONV.	62.64	15.1	18.9
Winnipeg-Edmonton	R16e	CONV.	62.64	15.1	15.1
Montreal-Ottawa	R1	LRC	15.13	7.1	40.0
Montreal-Ottawa	R1a	LRC	15.13	7.1	35.5
Montreal-Ottawa	R1b	LRC	15.13	7.1	17.8
Montreal-Ottawa	R1c	LRC	15.13	7.1	11.8
Montreal-Ottawa	R1d	LRC	15.13	7.1	8.9
Montreal-Ottawa	R1e	LRC	15.13	7.1	7.1

TABLE 3.8
DETAILED RAIL COST ANALYSIS - % BREAKDOWN

	RDC Low Density	RDC Inc. MSB Low Density	RDC Inc. MSB High Density	CONV. Low Density	CONV. Overniter Low Density	CONV. High Density	LRC High Density
Capital							
Locomotive	2.4	1.55	1.75	1.3	1.0	1.5	1.4
Coach	-	1.55	1.75	1.0	1.3	1.2	2.5
Sub Total	2.4	3.10	3.50	2.3	2.3	2.7	3.9
Train Operations							
Equipment Maintenance	32.9	37.4	40.8	25.0	29.1	32.3	35.3
Crew	33.7	21.3	23.2	21.8	10.4	15.7	17.6
Fuel	3.3	3.3	3.6	3.1	2.9	3.9	2.1
Sub Total	69.9	62.0	67.6	49.9	42.4	51.9	55.0
Track Related Operations	6.6	8.3	7.3	11.4	8.3	11.4	10.2
Other Services							
On-Board	3.9	5.0	5.4	6.8	8.3	8.5	7.7
Station	2.7	3.3	5.4	4.6	19.4	8.5	7.7
Sub Total	6.6	8.3	10.8	11.4	27.7	17.0	15.4
Overhead							
Mark'g/Resev.	1.2	1.6	1.8	2.3	2.8	2.8	2.6
Gen. Admin.	13.3	16.7	9.0	22.7	16.5	14.2	12.9
Sub Total	14.5	18.3	10.8	25.0	19.3	17.0	15.5
TOTAL %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

These detailed costs are also illustrated graphically in Figure 3.3. The results expressed are a percent of the total cost by equipment type are summarized below.

Cost Account	Percent of Total Cost		
	RDC	Conventional	LRC
Capital	2.4 - 3.5	2.3 - 2.7	3.9
Train Operations	62.0 -69.9	42.4 -51.9	55.0
Track Related Operations	6.6 - 8.3	8.3 -11.4	10.2
Other Services	6.6 -10.8	11.4 -27.7	15.4
Overhead	10.8 -18.3	17.0 -25.0	15.5

LRC's exhibit the highest share (i.e., percent of total) of capital related costs. RDC's exhibit the highest share of operational related costs for rolling stock. Conventional rail exhibits the highest share of costs related to track operations, other services and overhead.

3.3 Application of the Bus Cost Model

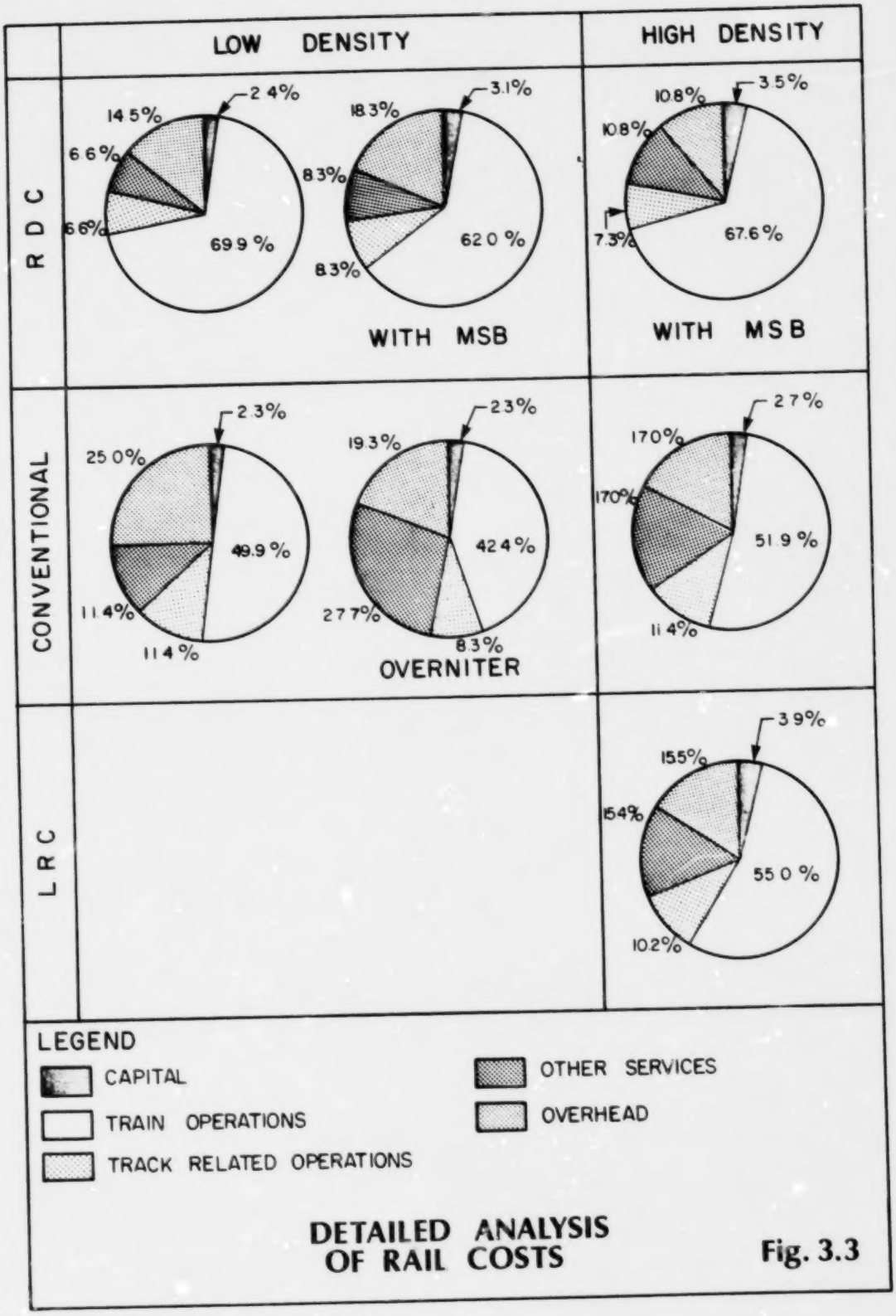
3.3.1 - Bus Service on the Selected Links

Presented in Table 3.9 are the service frequencies and travel times of bus routes operating between the major centres. In comparison to the rail mode (Table 3.1), bus service frequencies are higher ranging from a minimum of two, one-way trips per day on the long haul Winnipeg - Thompson route to over forty, one-way trips per day on the short-haul, high density Montreal - Ottawa run.

On short and medium haul runs (Montreal - Ottawa, Regina - Saskatoon, Sydney - Halifax and Toronto - Montreal) the scheduled travel times by bus are competitive with those of the rail mode. On the longer haul runs where travel by rail may be confined to long circuitous routes, such as between Winnipeg and Thompson or between Winnipeg and Edmonton, the bus mode offers the comparative advantage exhibiting travel times significantly lower than those of the rail mode.

3.3.2 - Bus Passenger Travel Volumes

Illustrated in Table 3.10 are estimates of current passenger travel, by bus, between the major centres. With the exception of the estimate provided for the North Vancouver - Prince George route, the figures presented are based on O-D travel volumes reported by others. The estimate of annual travel on the North Vancouver - Prince George route was developed, in consultation with the client, using secondary data sources.



DETAILED ANALYSIS OF RAIL COSTS

Fig. 3.3

The link volumes vary from a minimum of 5 000 person trips per annum on the Sydney - Halifax and Winnipeg - Edmonton routes to a maximum of 750 000 annual trips on the Montreal - Ottawa runs.

3.3.3 - Bus Scenarios

As identified previously, six alternate bus scenarious were considered in this investigation. Repeated below, they include the conventional bus; conventional buses with innovative attributes which provide an equivalent service to rail in terms of comfort, space and on-board services; high capacity buses and technological alternatives to the conventional bus which are considered feasible in the short term.

	Category	Scenario	Description
o	Conventional Bus	1	- 40' Bus, 45 Seats
o	Conventional Buses with Innovative On-Board Attributes	2	- 40' Bus, 30 Seats
		3	- 40' Bus, 22 Seats On Board Attendant On Board Meal Service
o	High Capacity Buses & Technological Alternatives	4	- 40' Bus, 45 Seats Improved Fuel Efficiency
		5	- 45' Bus, 53 Seats Improved Fuel Efficiency
		6	- High Capacity Bus, 75 Seats

A detailed description of each is presented in Section 2.3.5 of this report.

All six bus scenarios were tested on each of the seven inter-city study routes. Each scenario is labelled individually as Scenario **Bij**, where "i" represents the bus link under consideration (ranging from 1 to 7) and "j" represents the bus alternative being tested (ranging from 1 to 6). In total, forty-two (42) options were tested.

As in the case of the rail mode, bus scenarios are assigned the basic, scheduled service frequencies defined in Table 3.9. However, on the high density routes (Montreal - Ottawa and Toronto - Montreal) the number of bus departures is increased in response to the route demand. The maximum permitted load factor is 100 percent. The number of buses required is computed via the bus model (Program BUS 1) taking into consideration the route specific characteristics and passenger demand. No allowances are made to include vehicle spares.

TABLE 3.9
EXISTING BUS SERVICE CHARACTERISTICS

	City Pair	Dist. (km)	Travel Time (min)	Frequency M-T	Fri	Sat	Sun	Carrier
1.	Montreal - Ottawa			20	21	21	20	
	Ottawa - Montreal			20	20	20	20	
	Total	203	159	40	41	41	40	Voyageur
2.	Regina - Saskatoon			6	6	6	6	
	Saskatoon - Regina			6	6	6	6	
	Total	259	200	12	12	12	12	Saskatchewan
3.	Sydney - Halifax			3	3	3	3	
	Halifax - Sydney			3	3	3	3	
	Total	450	383	6	6	6	6	Acadian
4.	Toronto - Montreal			5	6	5	6	
	Montreal - Toronto			5	6	5	6	
	Total	574	395	10	12	10	12	Voyageur
5.	N. Vancouver - P. George			3	3	3	3	
	P. George - N. Vancouver			3	3	3	3	
	Total	805	780	6	6	6	6	Greyhound
6.	Winnipeg - Thompson			2	2	1	1	
	Thompson - Winnipeg			1	2	1	2	
	Total	766	598	3	4	2	3	Grey Goose
7.	Winnipeg - Edmonton			3	3	3	3	
	Edmonton - Winnipeg			3	3	3	3	
	Total	1 338	1 162	6	6	6	6	Greyhound

This study makes no attempt to project changes in bus ridership as a result of changes in on-board services or changes in technology. For example, having an on-board attendant and meal service may attract a greater number of users.

Although ridership is considered to be of importance, it is treated as an independant variable. The ridership level adopted for this segment of the analysis are those defined in Table 3.10. Other ridership levels are tested in Chapter 4 of this report to illustrate how the relative costs of rail and bus vary for different levels of utilization.

3.3.4 - Annual Bus Operations

Presented in Table 3.11 is a summary of annual operations and the corresponding costs generated by the bus model.

The performance measures by route include:

- Daily Bus Departures (total in both directions),
- Annual Vehicle - Kilometres,
- Annual Seat - Kilometres,
- Annual Passenger - Kilometres,
- Average Number of Passengers per Bus, based on the ratio of annual passenger - kilometres to annual vehicle - kilometres, and
- Average Load Factor, based on the ratio of annual passenger - kilometres to annual seat - kilometres.

On all routes but one (Winnipeg - Thompson), the performance measures are calculated on the basis of 365 service days per year. On the Winnipeg - Thompson route, the calculations are based on a weekend/weekday ratio of 0.50 which yields the equivalent of 312 service days per year.

Annual vehicle - kilometres range from a minimum of 959 000 on the Winnipeg - Thompson run (Scenarios B61 to B66) to a maximum of 7 039 000 on the Montreal - Ottawa route (Scenario B13).

Annual seat - kilometres vary between 21 099 000 (Scenario B63) and 238 956 000 (Scenario B16). Annual passenger - kilometres vary between 2 250 000 (Sydney - Halifax) and 152 250 000 (Montreal - Ottawa).

On the low density routes, operations are governed by the scheduled service frequencies. The resulting load factors are generally low ranging between 3.0 and 50.0 percent although some routes do exhibit higher load factors. On the two high density routes Montreal - Ottawa and Toronto - Montreal bus load factors are generally high ranging between 63.7 and 98.3 percent.

In general, bus load factors are significantly higher than those exhibited by the rail mode operating on the corresponding route.

TABLE 3.10
REPRESENTATIVE ANNUAL BUS PASSENGER FLOW VOLUMES

	City - Pair	2-Way Travel	Basis of Selection
1.	Montreal - Ottawa	750 000	o Reported 1977 O-D of 734 000 ("Via Rail Canada - an analyis of Via's potential in fulfilling rail passenger policy objectives, A.M. Khan, 1980)
2.	Regina - Saskatoon	40 000	o Reported 1979 O-D of 37 917 (TDC/Via Western Intercity Study)
3.	Sydney - Halifax	5 000	o Reported 1980 O-D of 3 600 ("Maritime Provinces Intermodal Passenger Study - Part 1" Transport Canada, 1983)
4.	Toronto - Montreal	200 000	o Reported 1977 O-D of 180 000 ("Via Rail Canada - an analysis of Via's potential in fulfilling rail passenger policy objectives," A.M. Khan, 1980)
5.	N. Vancouver - P. George	10 000	o Estimated by adopting the existing service schedule, an average system wide load factor of 48% provided by Greyhound and assuming 20% of riders travel the entire route.
6.	Winnipeg - Thompson	20 000	o Recent 12 month estimate provided by Grey Goose.
7.	Winnipeg - Edmonton	5 000	o Reported 1979 O-D of 4 940 (TDC/Via Western Intercity Study)

TABLE 3.11
SUMMARY OF ANNUAL BUS OPERATIONS AND COSTS

	Link	Scen.	Daily Dep.	Veh. -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Pass. Per Bus	Load Factor (%)	$Mill.	$Per Veh. -Km	¢Per Seat -Km	¢Per Pass. -Km
1.	Montreal - Ottawa	B11	47	3 482	156 711	152 250	44	97.2	4.86	1.40	3.1	3.2
		B12	71	5 261	157 822	152 250	29	96.5	6.71	1.28	4.3	4.4
		B13	95	7 039	154 859	152 250	22	98.3	9.10	1.29	5.9	6.0
		B14	47	3 482	156 711	152 250	44	97.2	4.68	1.34	3.0	3.1
		B15	43	3 186	168 863	152 250	48	90.2	4.35	1.37	2.6	2.9
		B16	43	3 186	238 956	152 250	48	63.7	5.09	1.60	2.1	3.3
2.	Regina - Saskatoon	B21	12	1 134	51 049	10 360	9	20.3	1.43	1.26	2.8	13.8
		B22	12	1 134	34 033	10 360	9	30.4	1.43	1.26	4.2	13.8
		B23	12	1 134	24 957	10 360	9	41.5	1.65	1.46	6.6	15.9
		B24	12	1 134	51 049	10 360	9	20.3	1.37	1.21	2.5	13.2
		B25	12	1 134	60 124	10 360	9	17.2	1.38	1.22	2.3	13.3
		B26	12	1 134	85 082	10 360	9	12.2	1.69	1.49	2.0	16.3
3.	Sydney - Halifax	B31	6	985	44 348	2 250	2	5.1	1.15	1.17	2.6	51.1
		B32	6	985	29 565	2 250	2	7.6	1.15	1.17	3.9	51.1
		B33	6	985	21 681	2 250	2	10.4	1.32	1.34	6.1	58.7
		B34	6	985	44 348	2 250	2	5.1	1.10	1.12	2.5	48.9
		B35	6	985	52 232	2 250	2	4.3	1.11	1.13	2.1	49.3
		B36	6	985	73 913	2 250	2	3.0	1.39	1.41	1.9	61.8
4.	Toronto - Montreal	B41	14	2 933	131 991	114 800	39	87.0	3.51	1.20	2.7	3.1
		B42	20	4 190	125 706	114 800	27	91.3	4.94	1.18	3.9	4.3
		B43	26	5 447	119 840	114 800	21	95.8	6.54	1.20	5.5	5.7
		B44	14	2 933	131 991	114 800	39	87.0	3.36	1.15	2.5	2.9
		B45	12	2 514	133 248	114 800	46	86.2	2.94	1.17	2.2	2.6
		B46	12	2 514	188 559	114 800	46	60.9	3.55	1.41	1.9	3.1

TABLE 3.11
SUMMARY OF ANNUAL BUS OPERATIONS AND COSTS
(Continued)

	Link	Scen.	Daily Dep.	Veh. -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Pass. Per Bus	Load Factor (%)	$Mill.	$Per Veh. -Km	¢Per Seat -Km	¢Per Pass. -Km
5.	N. Vancouver	B51	6	1 763	79 333	8 050	5	10.1	1.98	1.12	2.5	24.6
	- P. George	B52	6	1 763	52 889	8 050	5	15.2	1.98	1.12	3.7	24.6
		B53	6	1 763	38 785	8 050	5	20.8	2.34	1.33	6.0	29.1
		B54	6	1 763	79 333	8 050	5	10.1	1.89	1.07	2.4	23.5
		B55	6	1 763	93 436	8 050	5	8.6	1.90	1.08	2.0	23.6
		B56	6	1 763	132 221	8 050	5	6.1	2.33	1.32	1.8	28.9
6.	Winnipeg	B61	4	959	43 156	15 320	16	35.5	1.09	1.14	2.5	7.1
	- Thompson	B62	4	959	28 771	15 320	16	53.2	1.09	1.14	3.8	7.1
		B63	4	959	21 099	15 320	16	72.6	1.32	1.38	6.3	8.6
		B64	4	959	43 156	15 320	16	35.5	1.04	1.08	2.4	6.8
		B65	4	959	50 829	15 320	16	30.1	1.05	1.09	2.1	6.9
		B66	4	959	71 927	15 320	16	21.3	1.29	1.35	1.8	8.4
7.	Winnipeg	B71	6	2 930	131 860	6 690	2	5.1	3.16	1.08	2.4	47.2
	- Edmonton	B72	6	2 930	87 907	6 690	2	7.6	3.16	1.08	3.6	47.2
		B73	6	2 930	64 465	6 690	2	10.4	3.64	1.24	5.6	54.4
		B74	6	2 930	131 860	6 690	2	5.1	3.00	1.02	2.3	44.8
		B75	6	2 930	155 302	6 690	2	4.3	3.02	1.03	1.9	45.1
		B76	6	2 930	219 767	6 690	2	3.0	3.69	1.26	1.7	55.2

3.3.5 - Annual Operating Costs

The annual bus operating costs, expressed in absolute terms and in terms of unit costs per vehicle - kilometre, per seat - kilometre and per passenger - kilometre are presented in Table 3.11. Key results are illustrated graphically in Figure 3.4 and are summarized below:

- Of the six scenarios tested, Scenario 4, a fuel efficient bus (45 seats) and Scenario 5, a slightly longer fuel efficient bus (53 seats) consistently (regardless of route) exhibit the lowest operating costs per passenger-kilometre.

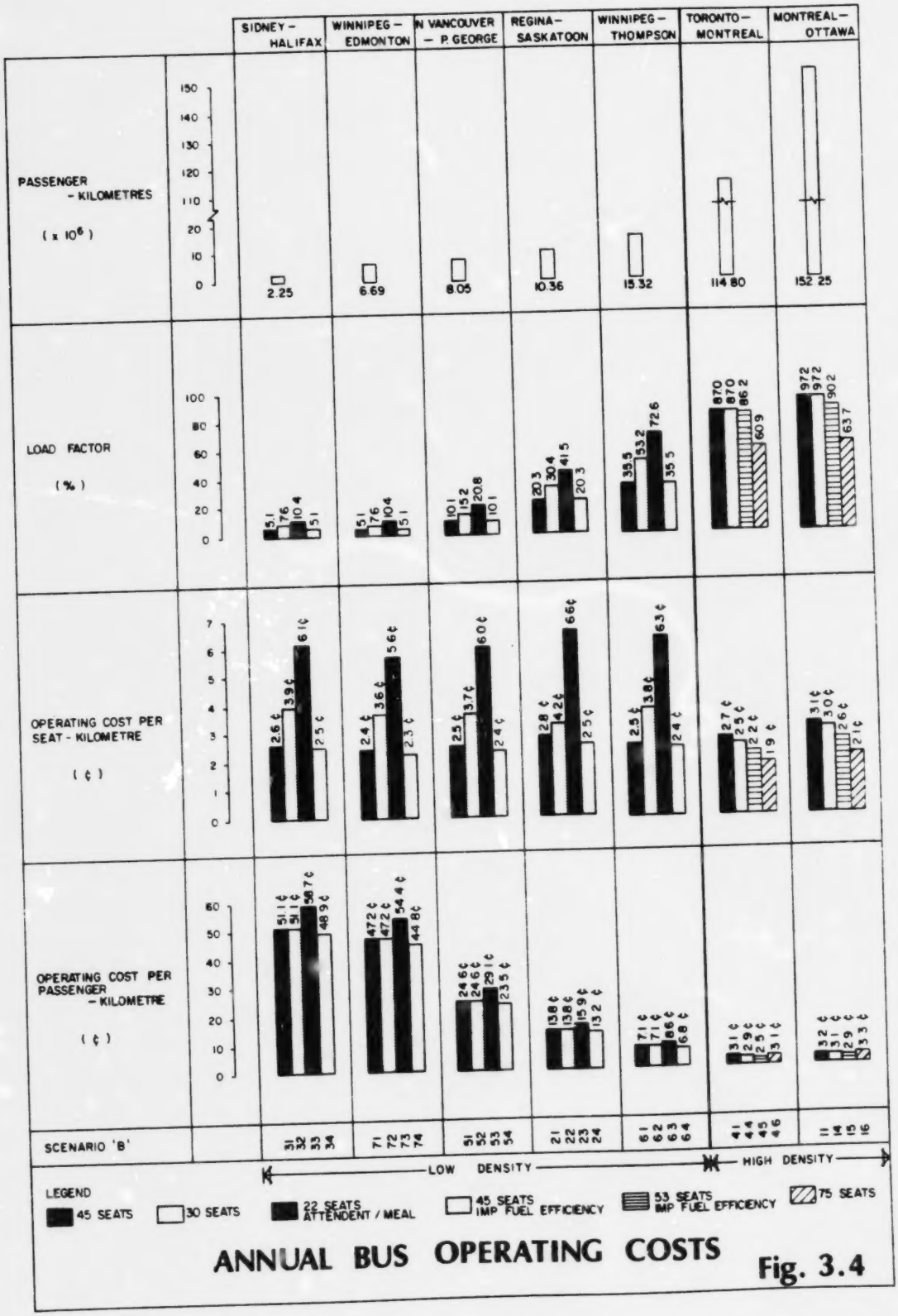
- As shown on the following table, Scenario 4 exhibits the lower of the two sets of values on low density routes, while Scenario 5 exhibits the lower values on high density routes.

Route	Cents Per Passenger-Kilometre	
	Scenario 4	Scenario 5
Low Density		
Sydney-Halifax	48.9	49.3
Winnipeg-Edmonton	44.8	45.1
North Vancouver-Prince George	23.5	23.6
Regina-Saskatoon	13.2	13.3
Winnipeg-Thompson	6.8	6.9
High Density		
Toronto-Montreal	2.9	2.6
Montreal-Ottawa	3.1	2.9

- These results suggest that the maximum improvement in cost performance can be derived by directing efforts towards one major area, specifically the development of improved fuel efficient engines. If the unit values assumed in Table 2.6 are valid, then the savings in fuel costs should offset the increased capital cost.

- These results also imply that there is an additional marginal benefit to be gained by the operation of slightly longer buses (53 seats) on high density routes.

  For example, on the Toronto-Montreal run, twelve 53-seat buses would provide the same capacity as fourteen 45-seat buses (refer to Scenarios B45 and B44, respectively). By running a fewer number of larger buses, the operator would save on capital, driver and maintenance related elements.



ANNUAL BUS OPERATING COSTS

Fig. 3.4

However, care must be taken to ensure that the number of daily bus departures is not reduced significantly in order not to impact negatively on existing bus ridership.

- There is no comparative advantage to be gained by operating higher capacity vehicles (i.e., anything in excess of 45 seats) on low density routes - where 45 seat vehicles provide ample seating capacity.

- As shown by Table 3.11, there does not appear to be any significant benefit to be gained by going to 75 seat buses, even on the high density routes considered.

  Whereas each bus may provide an increased seating capacity, the minimum volume of buses (in the case of this experiment) is governed by the basic scheduled service frequency. For example, consider Scenarios B45 (53 seat bus) and Scenario B46 (75 seat bus). In both cases, there are twelve (12) bus departures per day (i.e, minimum daily service frequency). In the first case, the load factor equals 86.2 percent. In the latter, the load factor is lower at 60.9 percent. If this basic service frequency is maintained, then the opportunity to offset the additional cost per vehicle disappears. The results are lower load factors and the use of larger buses which cost more.

  If the basic service frequency is sacrificed in favour of a fewer number of high capacity 75 seat buses, there is likely to be a reduction in the volume of bus passengers (i.e., riders may elect to use alternate modes featuring equal or more attractive service frequencies). This reduction may be sufficient to offset the anticipated cost savings.

- The results suggest that there is no advantage to be gained by operating reduced capacity vehicles (anything lower than 45 seats) or by providing on-board services on high density routes. As shown by the Toronto-Montreal and Montreal-Ottawa runs (Table 3.9), both the numbers of buses required and the corresponding costs increase significantly.

- Although not shown by the results presented in Table 3.11, there can be a cost advantage associated with the operation of either a 30-seat or a 22-seat bus on low density routes provided that the operator initiates a marketing effort (to advertise the additional space and on-board service in the case of a 22-seat bus) directed to the attraction of additional riders.

  A 30-seat bus becomes viable with only a minor increase in ridership - sufficient to offset the increased marketing costs.

  Based on the figures presented in Table 3.11, to be a viable option, the 22-seat bus requires at the least, a 20 percent increase in ridership to offset the increased capital and operational expenses as well as the marketing costs.

The reader is reminded that this segment of the analysis is predicated on a series of assumptions presented in Section 2.3.5. Specifically, these assumptions pertain to the unit costs by account selected for non-conventional vehicles and operations.

It is left to the reader to judge the validity of the input parameters and the degree of reliability of these results. Of course, the user may repeat this experiment using any set of input parameters deemed appropriate.

3.3.6 - Detailed Cost Analysis

Presented in Table 3.12 are detailed costs by cost account for each of the scenarios tested. Results for a typical low density route (Sydney - Halifax) are presented graphically in Figure 3.5 and are reviewed below:

Relative to the conventional 45-seat bus (Scenario 1);

- Scenario 2, a bus featuring 30 seats exhibits no appreciable differences.
- Scenario 3, featuring a reduced seating capacity of 22 seats and on-board services, exhibits a sharp reduction in the respective shares in all conventional cost accounts to offset the cost of in-vehicle service.
- Scenario 4, a bus featuring an improved fuel efficient engine exhibits a slightly lower share of vehicle related expenses primarily due to lower fuel costs. This reduction is offset by a higher share of maintenance expenses.
- Scenario 5, a slightly larger bus with 53 seats and a fuel efficient engine exhibits results similar to those of Scenario 4.
- Scenario 6, a high capacity bus exhibits a significant increase in the share of vehicle related expenses offset by reductions in all other cost accounts.

Results for a typical high density route (Montreal - Ottawa) are presented graphically in Figure 3.6.

Relative to the conventional 45-seat bus (Scenario 1);

- Scenario 2, featuring 30 seats exhibits increased shares of driver, vehicle and maintenance expenses. These are attributed primarily to the increase in number of buses and drivers required (over that of the conventional vehicle) to accommodate the route demand.
- Scenario 3 exhibits increased shares in vehicle and maintenance expenses again in response to the increased volume of buses required. Driver expenses, however, do not increase proportionally. In fact, these expenses are shown to decrease along with other cost accounts to offset in-vehicle service costs.

TABLE 3.12
DETAILED BUS COST ANALYSIS - % BREAKDOWN

	Link	Cost Account	SCENARIO 1 Conventional 45 Seats	2 Conventional 30 Seats	3 Conventional 22 Seats Att./Meal	4 Technological Alternatives 45 Seats IFE*	5 Technological Alternatives 53 Seats IFE	6 Technological Alternatives 75 Seats
1.	Montreal - Ottawa	Driver Expenses	23.8	25.6	11.8	24.8	23.7	22.3
		Vehicle Expenses	19.5	21.9	21.1	16.4	15.9	23.5
		In-Vehicle Service	-	-	20.0	-	-	-
		Terminal Exp.	25.7	18.6	13.7	26.7	28.7	24.5
		Maintenance	18.7	20.5	20.2	19.5	19.2	19.1
		Admin. and General	12.3	13.4	13.3	12.6	12.5	10.6
		Total %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
2.	Regina - Saskatoon	Driver Expenses	34.9	34.9	30.2	36.3	36.1	32.3
		Vehicle Expenses	26.1	26.1	23.1	23.1	23.6	31.9
		In-Vehicle Service	-	-	12.9	-	-	-
		Terminal Exp.	4.7	4.7	4.1	4.9	4.8	3.9
		Maintenance	20.8	20.8	18.0	21.6	21.5	20.4
		Admin. and General	13.5	13.5	11.7	14.1	14.0	11.5
		Total %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

* IFE - Improved Fuel Efficiency

TABLE 3.12
DETAILED BUS COST ANALYSIS - % BREAKDOWN
(Continued)

	Link	Cost Account	SCENARIO 1 Conventional 45 Seats	2 Conventional 30 Seats	3 Conventional 22 Seats Att./Meal	4 Technological Alternatives 45 Seats IFE*	5 Technological Alternatives 53 Seats IFE	6 Technological Alternatives 75 Seats
3.	Sydney-Halifax	Driver Expenses	32.3	32.3	28.2	33.7	33.4	29.4
		Vehicle Expenses	29.9	29.9	26.7	26.9	27.5	36.3
		In-vehicle Service	-	-	12.2	-	-	-
		Terminal Exp.	0.7	0.7	0.6	0.8	0.8	0.6
		Maintenance	22.5	22.5	19.6	23.4	23.2	21.6
		Admin. and General	14.6	14.6	12.7	15.2	15.1	12.1
		Total %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
4.	Toronto - Montreal	Driver Expenses	32.6	33.1	16.3	34.1	33.4	30.5
		Vehicle Expenses	21.9	23.5	23.0	18.3	18.4	26.5
		In-Vehicle Service	-	-	19.7	-	-	-
		Terminal Exp.	9.5	6.7	5.1	9.9	11.3	9.4
		Maintenance	21.8	22.2	21.8	22.8	22.3	21.6
		Admin. and General	14.2	14.5	14.1	14.9	14.6	12.0
		Total %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

* IFE - Improved Fuel Efficiency

TABLE 3.12
DETAILED BUS COST ANALYSIS - % BREAKDOWN
(Continued)

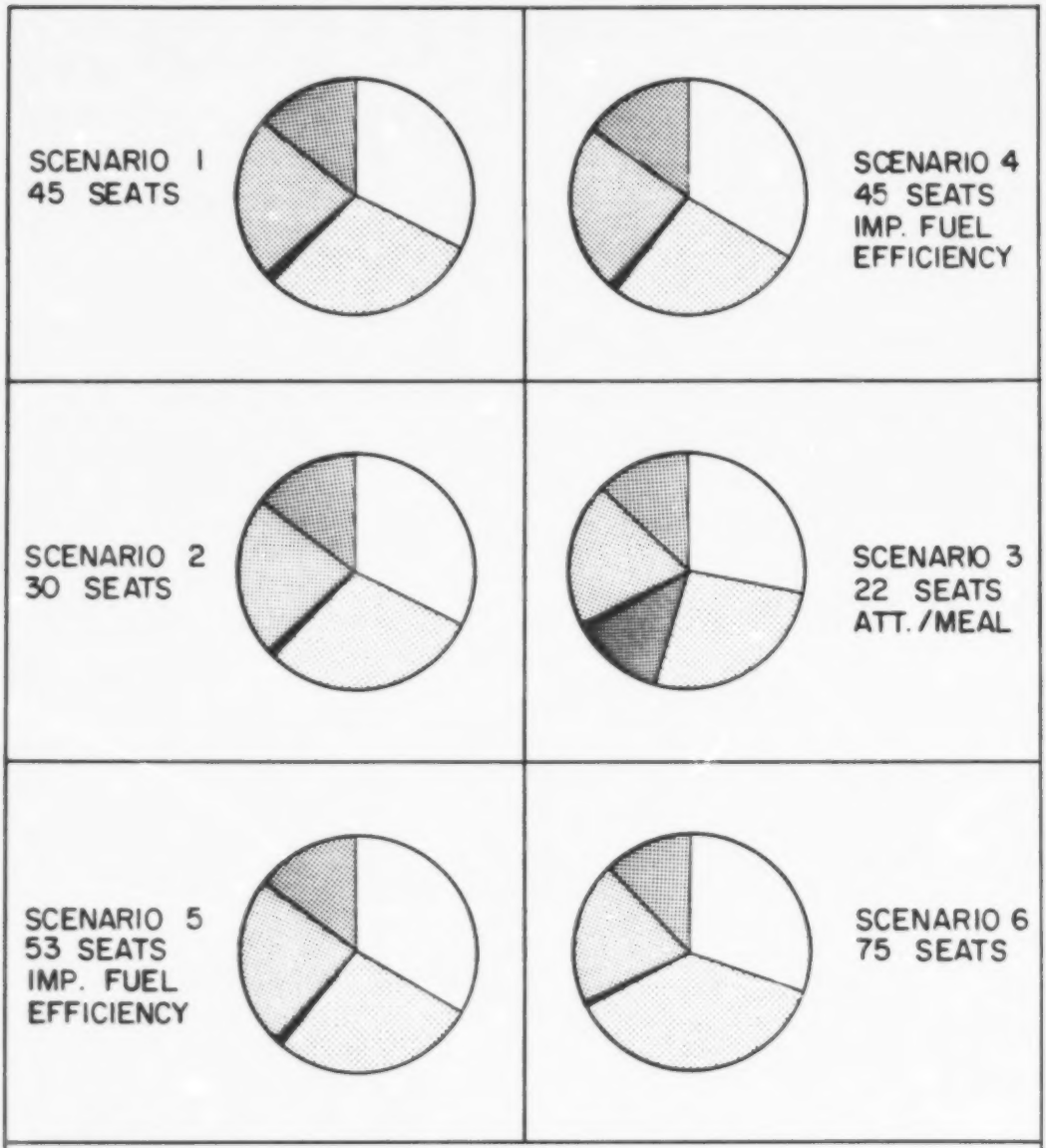
	Link	Cost Account	SCENARIO 1 Conventional 45 Seats	2 Conventional 30 Seats	3 Conventional 22 Seats Att./Meal	4 Technological Alternatives 45 Seats IFE*	5 Technological Alternatives 53 Seats IFE	6 Technological Alternatives 75 Seats
5.	N. Vancouver - P. George	Driver Expenses	37.2	37.2	31.5	39.0	38.8	34.8
		Vehicle Expenses	23.6	23.6	20.2	19.8	20.2	28.5
		In-Vehicle Service	-	-	15.0	-	-	-
		Terminal Exp.	0.9	0.9	0.7	0.9	0.9	0.7
		Maintenance	23.2	23.2	19.7	24.4	24.3	23.1
		Admin. and General	15.0	15.0	12.9	15.9	15.8	12.9
		Total %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
6.	Winnipeg - Thompson	Driver Expenses	34.6	34.6	28.6	36.2	36.0	32.3
		Vehicle Expenses	24.1	24.1	20.2	20.4	20.8	29.2
		In-Vehicle Service	-	-	17.0	-	-	-
		Terminal Exp.	3.1	3.1	2.5	3.2	3.2	2.6
		Maintenance	23.2	23.2	19.2	24.4	24.2	23.0
		Admin. and General	15.0	15.0	12.5	15.8	15.8	12.9
		Total %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

* IFE - Improved Fuel Efficiency

TABLE 3.12
DETAILED BUS COST ANALYSIS - % BREAKDOWN
(Continued)

Link	Cost Account	SCENARIO 1	2	3	4	5	6
			Conventional		Technological Alternatives		
		45 Seats	30 Seats	22 Seats Att./Meal	45 Seats IFE*	53 Seats IFE	75 Seats
7. Winnipeg - Edmonton	Driver Expenses	37.1	37.1	32.2	39.0	38.9	34.9
	Vehicle Expenses	22.6	22.6	19.9	18.6	18.9	27.2
	In-Vehicle Service	-	-	13.0	-	-	-
	Terminal Exp.	0.3	0.3	0.2	0.3	0.3	0.2
	Maintenance	24.2	24.2	21.0	25.5	25.4	24.2
	Admin. and General	15.8	15.8	13.7	16.6	16.5	13.5
	Total %	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

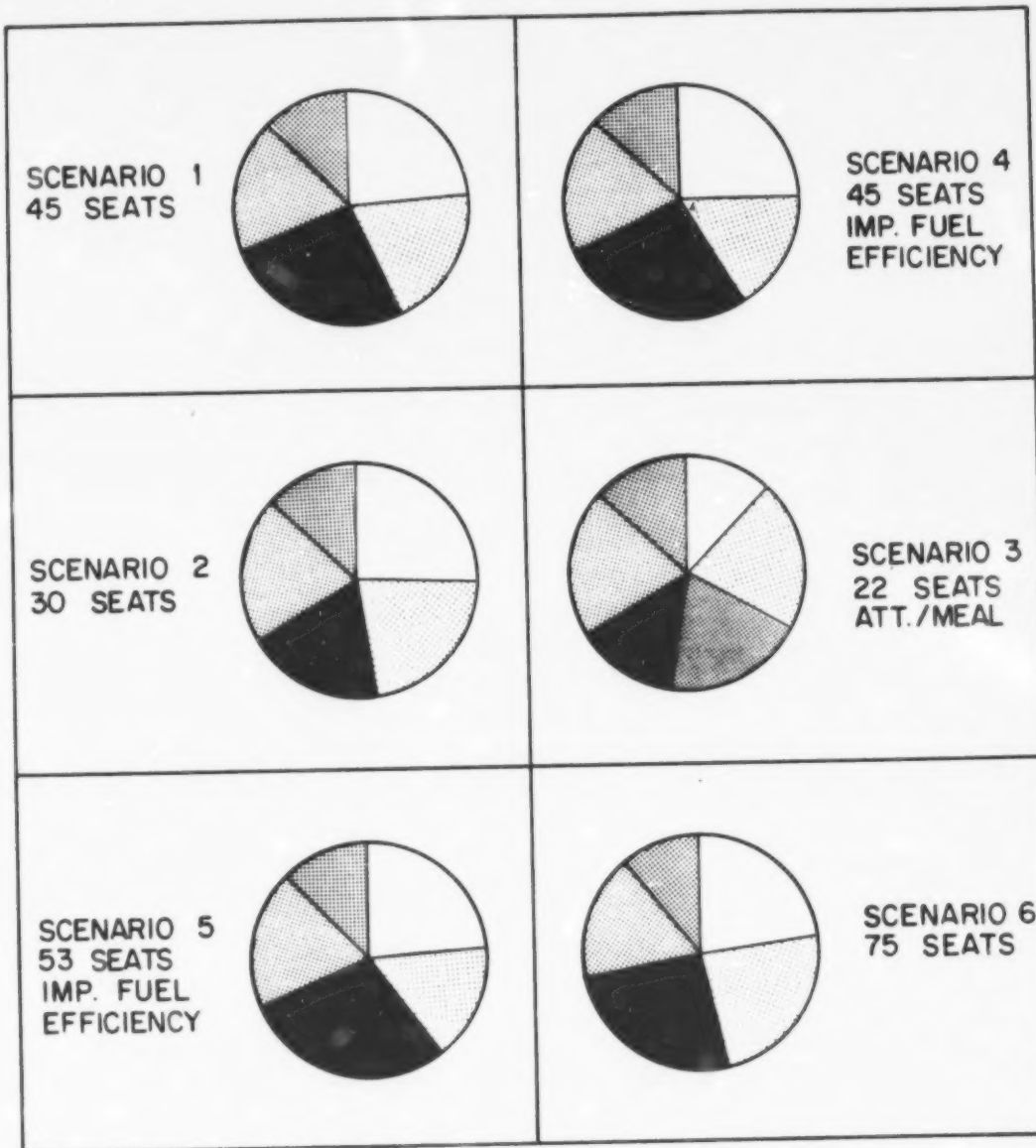
* IFE - Improved Fuel Efficiency



DETAILED ANALYSIS OF BUS COSTS

SYDNEY-HALIFAX

Fig. 3.5



DETAILED ANALYSIS OF BUS COSTS

MONTREAL - OTTAWA

Fig. 3.6

- Scenario 4 exhibits slightly lower shares in vehicle related expenses due primarily to lower fuel costs. This reduction is offset by slight increases in the other cost accounts.

- Scenario 5 exhibits results which are similar to those of Scenario 4.

- Scenario 6 exhibits a significant increase in the share of vehicle related expenses offset by reductions in other cost accounts.

The most significant difference between the two sets of results (Figures 3.5 and 3.6) are the costs pertaining to terminal expenses. These costs are generated by the cost model as a function of the volume of passengers passing through the terminal. On high density routes such expenses may represent over 25 percent of the total operating cost. On low density routes terminal expenses relative to the other cost accounts are not significant.

4. COMPARISON OF RAIL/BUS ALTERNATIVES

In Section 3.2, rail costs were estimated on the basis of existing rail passenger flows and a comparison was made among the rail alternatives in order to evaluate the comparative "within mode" advantages of various rail technologies.

In Section 3.3, bus costs were estimated on the basis of existing bus passenger flows and a similar comparison was made among the bus alternatives addressing the comparative advantages of the various bus technologies and services considered.

In this chapter, rail and bus costs are determined for equal passenger flows and a "between mode" comparison is undertaken. Since equal passenger levels are assumed for this segment of the investigation, comparisons of cost performance can be made in terms of both unit and total costs.

4.1 Passenger Flows

For the purposes of this phase of the study, the following passenger flows were adopted.

Route	Annual 2-Way Travel
Montreal - Ottawa	950 000
Regina - Saskatoon	47 500
Sydney - Halifax	20 000
Toronto - Montreal	680 000
North Vancouver - Prince George	15 000
Winnipeg - Thompson	25 000
Winnipeg - Edmonton	30 000

These figures were developed by combining the existing rail passenger flows presented in Table 3.2 with the existing bus passenger flows presented in Table 3.10.

4.2 Performance of Rail Alternatives

Presented in Table 4.1 are the rail alternatives selected for this segment of the study. There are a total of fourteen listed as Scenarios RC1 to RC14.

The alternatives include LRC and conventional rail equipment on the high density runs, and RDC and conventional rail equipment on those of low density. The consist configurations vary according to the type of equipment under consideration, the volume of passenger traffic and the stage length.

In general, the scenarios are assigned the existing weekday, scheduled service frequencies as defined earlier in Table 3.3.

Presented in Table 4.2 are the operational attributes exhibited by the rail alternatives under consideration expressed in terms of annual train - kilometres, annual locomotive - kilometres, annual car - kilometres, annual seat - kilometres, annual passenger - kilometres, average number of passengers per train and the average load factor.

On low density routes, passenger rail load factors range between 9.8 and 45.5 percent. On high density routes they range between 47.1 and 73.0 percent.

Annual operating costs, expressed in terms of total and unit values, are presented in Table 4.3.

4.3 Performance of Bus Alternatives

All six of the bus scenarios described previously (Section 2.3.5) were tested on each of the study routes. Presented in Table 4.4 are the operational and cost performances exhibited.

Each scenario is labelled individually as Scenario Cij, where "i" represents the bus links (ranging from 1 to 7) and "j" represents the bus alternative (ranging from 1 to 6)

As in the previous application, (Section 3.3.3), bus scenarios are assigned the basic scheduled weekday service frequency. However, on high density runs the number of buses required is computed by means of the bus model assuming a maximum load factor of 100 percent. Accordingly, on high density routes the number of bus departures may exceed the basic scheduled service frequency.

The scenarios cover a broad spectrum of operations. Bus load factors range between 9.1 and 98.3 percent. Total costs range between $1.05 million and $19.38 million.

4.4 Comparison Between Modes

Presented in the following figures are the key performance and unit costs generated by the rail and bus models for each of the scenarios considered. The results are presented by route. The North Vancouver-Prince George run, bearing the lowest passenger flow assignment (15 000 passengers per annum) is addressed first (Figure 4.1). Each of the other runs is subsequently addressed, in turn, according to increasing passenger flow assignments. The Montreal-Ottawa run, bearing the highest value (950 000 passengers per annum) is shown last (Figure 4.7).

Despite equal passenger levels, the rail and bus modes exhibit different passenger related performance characteristics.

TABLE 4.1
RAIL SCENARIOS SELECTED FOR RAIL/BUS COMPARISONS

	City - Pair	Scenario	Annual O-D	Daily Freq. (2-way)	Equipment and Consist (Typical)	Cars Per Train	Seats Per Train
1.	Montreal - Ottawa	RC1	950 000	12	LRC: 1PV + 4C + 1CL	6	354
		RC2	950 000	12	CONV: 2PV + 4C + 1CL + 1D	8	320
2.	Regina - Saskatoon	RC3	47 500	4	RDC: 1RDC	1	77
		RC4	47 500	4	RDC: RDC + MSB	2	124
3.	Sydney - Halifax	RC5	20 000	4	RDC: 1RDC	1	77
		RC6	20 000	2	RDC: RDC + MSB	2	124
		RC7	20 000	4	RDC: RDC + MSB	2	124
4.	Toronto - Montreal	RC8	680 000	12	LRC: 1PV + 4C + 1CL	6	354
		RC9	680 000	12	CONV: 2PV + 3C + 1CL + 1DN + 1	8	320
5.	N. Vancouver - P. George	RC10	15 000	2	CONV: 1PV + 1C + 1CL + 1	4	108
		RC11	15 000	2	RDC: RDC + MSB	2	124
6.	Winnipeg - Thompson	RC12	25 000	2	CONV: 1PV + 2C + 2S + 1CL + 2D + 1	9	228
		RC13	25 000	2	CONV: 1 PV + 1C + 1CL + 1	4	108
7.	Winnipeg - Edmonton	RC14	30 000	2	CONV: 3PV + 3C + 2DN + 6S + 4	18	416

Legend

PV - Power Unit C - Coach CL - Club Car DN - Dayniter D - Dinette MSB - Modified Snack Bar
S - Sleeper

TABLE 4.2
OPERATIONAL PERFORMANCE OF RAIL ALTERNATIVES

Link	Scenario	Equip.	Train-Km (000's)	Loc.-Km (000's)	Car-Km (000's)	Seat-Km (000's)	Pass.-Km (000's)	Passengers Per Train	Load Factor (%)
1. Montreal - Ottawa	RC1	LRC	761	761	4 564	270 054	177 650	233	65.8
	RC2	CONV.	761	1 521	6 086	243 429	177 650	233	73.0
2. Regina - Saskatoon	RC3	RDC	357	357	357	27 460	12 493	35	45.5
	RC4	RDC	357	357	713	44 222	12 493	35	28.3
3. Sydney - Halifax	RC5	RDC	641	641	641	49 387	9 460	15	19.2
	RC6	RDC	321	321	641	39 766	9 460	29	23.8
	RC7	RDC	641	641	1 283	79 532	9 460	15	11.9
4. Toronto - Montreal	RC8	LRC	2 193	2 193	13 156	778 391	366 520	167	47.1
	RC9	CONV.	2 193	4 385	17 541	701 649	366 520	167	52.2
5. N. Vancouver - P. George	RC10	CONV.	504	504	2 018	54 479	11 160	22	20.5
	RC11	RDC	504	504	1 009	62 550	11 160	22	17.8
6. Winnipeg - Thompson	RC12	CONV.	779	779	7 011	179 175	28 725	37	16.0
	RC13	CONV.	779	779	3 116	84 134	28 725	37	34.1
7. Winnipeg - Edmonton	RC14	CONV.	991	2 972	17 831	414 075	40 710	41	9.8

TABLE 4.3
ANNUAL OPERATING COSTS OF RAIL ALTERNATIVES

Link	Seen.	Equip.	$ Millions	$ Per Train -Km	$ Per Car -Km	¢ Per Seat -Km	¢ Per Pass. -Km
1. Montreal - Ottawa	RC1	LRC	17.33	22.77	3.79	6.4	10
	RC2	CONV.	20.81	27.35	3.42	8.6	12
2. Regina - Saskatoon	RC3	RDC	2.71	7.59	7.59	9.9	22
	RC4	RDC	4.30	12.04	6.03	9.7	34
3. Sydney - Halifax	RC5	RDC	4.88	7.61	7.61	9.9	52
	RC6	RDC	3.86	12.02	6.02	9.7	41
	RC7	RDC	7.73	12.06	6.02	9.7	82
4. Toronto - Montreal	RC8	LRC	49.94	22.77	3.80	6.4	14
	RC9	CONV.	59.97	27.35	3.42	8.6	16
5. N. Vancouver - P. George	RC10	CONV.	8.88	17.62	4.40	16.3	80
	RC11	RDC	6.08	12.06	6.03	9.7	54
6. Winnipeg - Thompson	RC12	CONV.	26.11	33.52	3.72	14.6	91
	RC13	CONV.	13.71	17.60	4.40	16.3	48
7. Winnipeg - Edmonton	RC14	CONV.	62.64	63.21	3.51	15.1	154

TABLE 4.4
OPERATIONAL AND COST PERFORMANCE OF BUS ALTERNATIVES

	Link	Scen.	Daily Dep.	Veh. -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Pass. Per Bus	Load Factor (%)	$Mill.	$Per Veh. -Km	¢Per Seat -Km	¢Per Pass. -Km
1.	Montreal - Ottawa	C11	59	4 372	196 722	192 850	44	98.0	6.15	1.41	3.1	3.2
		C12	89	6 594	197 834	192 850	29	97.5	7.35	1.11	3.7	3.8
		C13	121	8 965	197 241	192 850	22	97.8	11.46	1.28	5.8	5.9
		C14	59	4 372	196 722	192 850	44	98.0	5.93	1.36	3.0	3.1
		C15	51	3 779	200 279	192 850	51	96.3	5.35	1.42	2.7	2.8
		C16	43	3 186	238 956	192 850	61	80.7	5.42	1.70	2.3	2.8
2.	Regina - Saskatoon	C21	12	1 134	51 049	12 303	11	24.1	1.44	1.27	2.8	11.7
		C22	12	1 134	34 033	12 303	11	36.2	1.44	1.27	4.2	11.7
		C23	12	1 134	24 957	12 303	11	49.3	1.67	1.47	6.7	13.6
		C24	12	1 134	51 049	12 303	11	24.1	1.38	1.22	2.7	11.2
		C25	12	1 134	60 124	12 303	11	20.5	1.39	1.23	2.3	11.3
		C26	12	1 134	85 082	12 303	11	14.5	1.71	1.51	2.0	13.9
3.	Sydney - Halifax	C31	6	986	44 348	9 000	9	20.3	1.17	1.19	2.6	13.0
		C32	6	986	29 565	9 000	9	30.4	1.17	1.19	4.0	13.0
		C33	6	986	21 681	9 000	9	41.5	1.39	1.41	6.4	15.4
		C34	6	986	44 348	9 000	9	20.3	1.13	1.15	2.5	12.6
		C35	6	986	52 232	9 000	9	17.2	1.13	1.15	2.2	12.6
		C36	6	986	73 913	9 000	9	12.2	1.41	1.43	1.9	15.7
4.	Toronto - Montreal	C41	42	8 799	395 974	390 320	44	98.6	8.40	0.95	2.1	2.2
		C42	64	13 409	402 259	390 320	29	97.0	11.69	0.87	2.9	3.0
		C43	86	18 018	396 393	390 320	22	98.5	19.38	1.08	4.9	5.0
		C44	42	8 799	395 974	390 320	44	98.6	7.94	0.90	2.0	2.0
		C45	36	7 542	399 745	390 320	52	97.6	7.14	0.95	1.8	1.8
		C46	26	5 447	408 545	390 320	72	95.5	7.00	1.29	1.7	1.8

TABLE 4.4
OPERATIONAL AND COST PERFORMANCE OF BUS ALTERNATIVES
(Continued)

Link	Scen.	Daily Dep.	Veh. -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Pass. Per Bus	Load Factor (%)	$Mill.	$Per Veh. -Km	¢Per Seat -Km	¢Per Pass. -Km
5. N. Vancouver - P. George	C51	6	1 763	79 333	12 075	7	15.2	1.99	1.13	2.5	16.5
	C52	6	1 763	52 889	12 075	7	22.8	1.99	1.13	3.8	16.5
	C53	6	1 763	38 785	12 075	7	31.1	2.38	1.35	6.1	19.7
	C54	6	1 763	79 333	12 075	7	15.2	1.90	1.08	2.4	15.7
	C55	6	1 763	93 436	12 075	7	12.9	1.91	1.08	2.0	15.8
	C56	6	1 763	132 221	12 075	7	9.1	2.33	1.32	1.8	19.3
6. Winnipeg - Thompson	C61	4	959	43 156	19 150	20	44.4	1.10	1.15	2.5	5.7
	C62	4	959	28 771	19 150	20	66.6	1.10	1.15	3.8	5.7
	C63	4	959	21 099	19 150	20	90.8	1.36	1.42	6.4	7.1
	C64	4	959	43 156	19 150	20	44.4	1.05	1.09	2.4	5.5
	C65	4	959	50 829	19 150	20	37.7	1.06	1.11	2.1	5.5
	C66	4	959	71 927	19 150	20	26.6	1.29	1.35	1.8	6.7
7. Winnipeg - Edmonton	C71	6	2 930	131 860	40 140	14	30.4	3.20	1.09	2.4	8.0
	C72	6	2 930	87 907	40 140	14	45.7	3.20	1.09	3.6	8.0
	C73	6	2 930	64 465	40 140	14	62.3	3.92	1.34	6.1	9.8
	C74	6	2 930	131 860	40 140	14	30.4	3.05	1.04	2.3	7.0
	C75	6	2 930	155 302	40 140	14	25.8	3.06	1.04	2.0	7.6
	C76	6	2 930	219 767	40 140	14	18.3	3.73	1.27	1.7	9.3

One illustration is the number of passenger-kilometres generated.

	Passengers	Passenger - Kilometres		Difference
		Rail ($x10^6$)	Bus ($x10^6$)	(%)
North Vancouver - Prince George	15 000	11.2	12.1	8.0%
Sydney - Halifax	20 000	9.46	9.0	4.9%
Winnipeg - Thompson	25 000	28.7	19.2	49.5%
Winnipeg - Edmonton	30 000	40.7	40.1	1.5%
Regina - Saskatoon	47 500	12.5	12.3	1.6%
Toronto - Montreal	680 000	366.5	390.3	6.5%
Montreal - Ottawa	950 000	177.7	192.9	8.6%

With one exception (Winnipeg - Thompson) the differences are small, i.e., less than 10 percent, and should not adversely impact on this analysis "between the modes". Due to the significant difference exhibited by the Winnipeg - Thompson link (49.5 percent), the results on that route should be interpreted with caution.

Another illustration is the average load factor exhibited by each of the scenarios considered. Parameters governing the rail load factor include the service frequency adopted, the equipment type, the consist configuration and corresponding seating capacity. Parameters governing the bus load factor include the service frequency, the number of buses generated by the bus model, the type of bus and corresponding seating capacity. Presented in the following table are the range of load factors generated (for the various alternate scenarios) by route.

	Load Factors	
	Rail	Bus
North Vancouver - Prince George	17.8 - 20.5	9.1 - 31.1
Sydney - Halifax	11.9 - 23.8	12.2 - 41.5
Winnipeg - Thompson	16.0 - 34.1	26.6 - 90.8
Winnipeg - Edmonton	9.8	18.3 - 62.3
Regina - Saskatoon	28.3 - 45.5	14.5 - 49.3
Toronto - Montreal	47.1 - 52.2	95.5 - 98.6
Montreal - Ottawa	65.8 - 73.0	80.7 - 98.0

In general, the bus load factors exceed those exhibited by the rail mode. This result is not unexpected on the basis of the two different modelling approaches.

The following table presents the passenger level and total cost by link and by mode.

	Passengers	Total Estimated Cost $ Million	
		Rail	Bus
North Vancouver - Prince George	15 000	6.1 - 8.9	1.9 - 2.1
Sydney - Halifax	20 000	3.9 - 7.7	1.1 - 1.4
Winnipeg - Thompson	25 000	13.7 - 26.1	1.1 - 1.4
Winnipeg - Edmonton	30 000	62.6	3.1 - 3.9
Regina - Saskatoon	47 500	2.7 - 4.3	1.4 - 1.7
Toronto - Montreal	680 000	49.9 - 60.0	7.0 - 19.8
Montreal - Ottawa	950 000	17.3 - 20.8	5.4 - 11.5

Clearly, by these results;

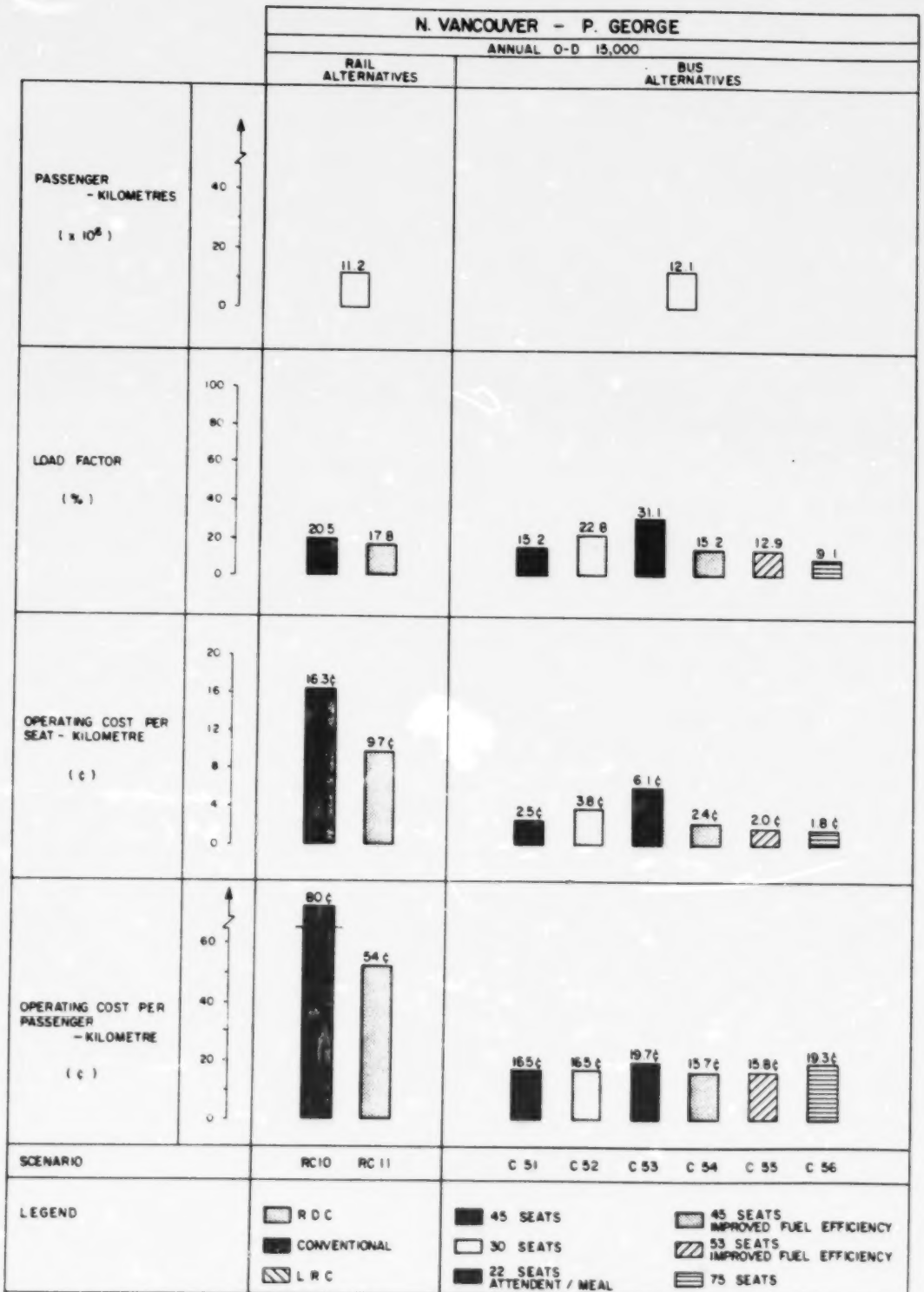
- Of the two modes, rail is the more expensive mode to operate.

  Presented below is the ratio of rail cost to bus cost, taking the lowest rail cost and the highest bus cost on each of the selected links.

	Rail/Bus Cost Ratio
North Vancouver-Prince George	2.9
Sydney-Halifax	2.8
Winnipeg-Thompson	9.8
Winnipeg-Edmonton	16.1
Regina-Saskatoon	1.6
Toronto-Montreal	2.5
Montreal-Ottawa	1.5

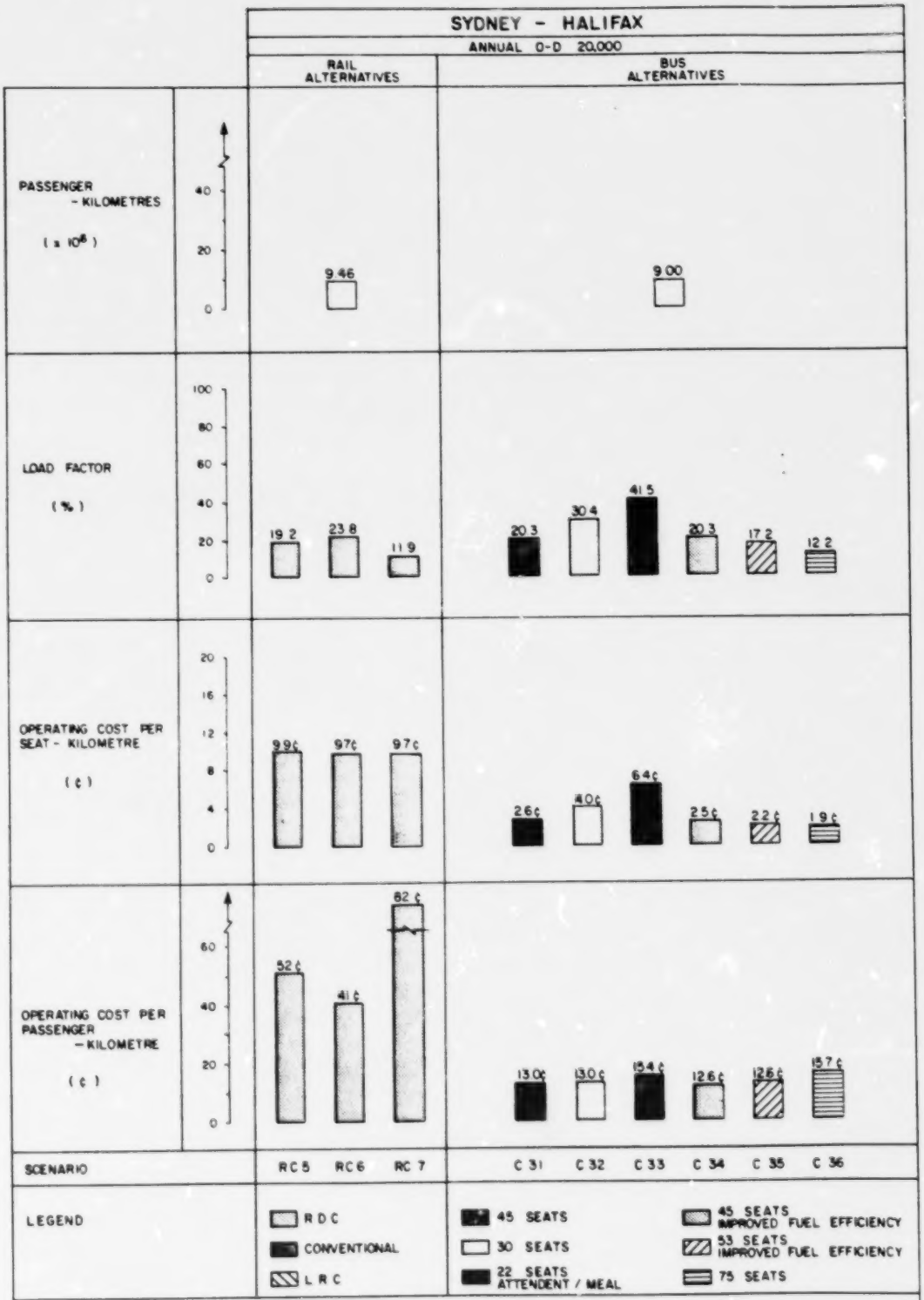
- All of the bus scenarios considered offer the comparative advantage with respect to cost performance.

- Rail service does not appear to be viable in the context of these extremely low link volumes.



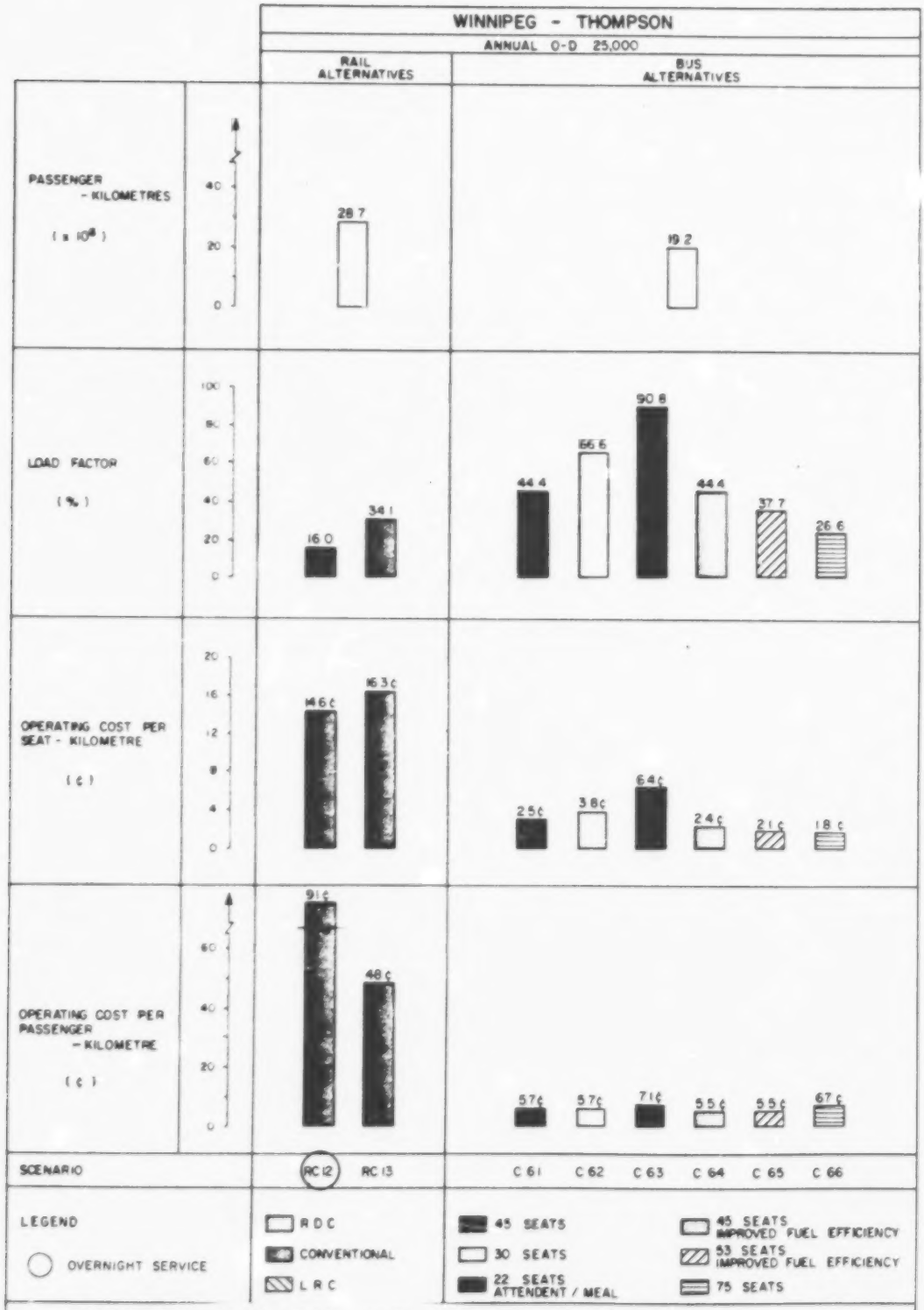
COMPARISON OF RAIL AND BUS OPERATING COSTS
N. VANCOUVER - P. GEORGE

Fig. 4.1



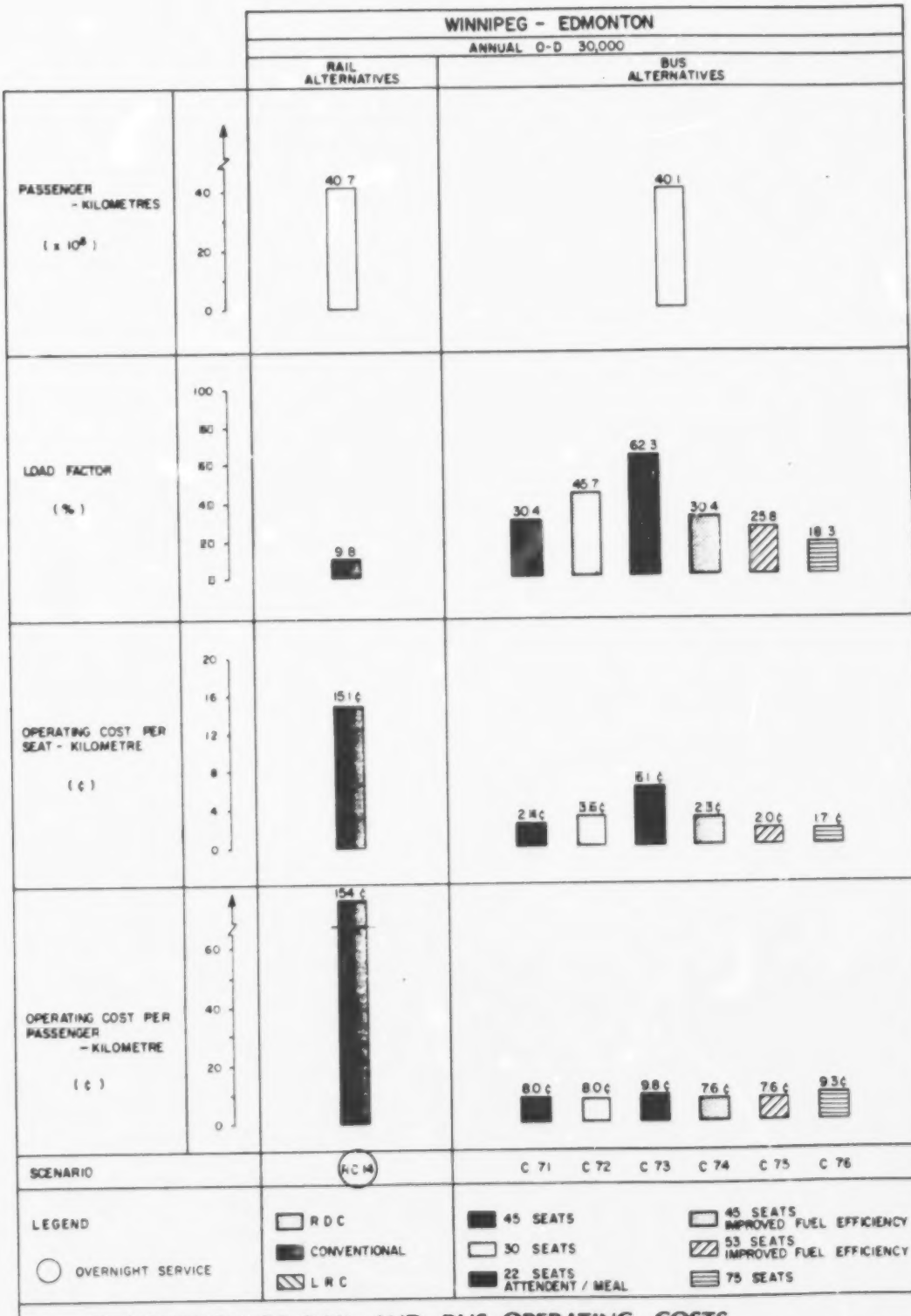
COMPARISON OF RAIL AND BUS OPERATING COSTS
SYDNEY - HALIFAX

Fig. 4.2



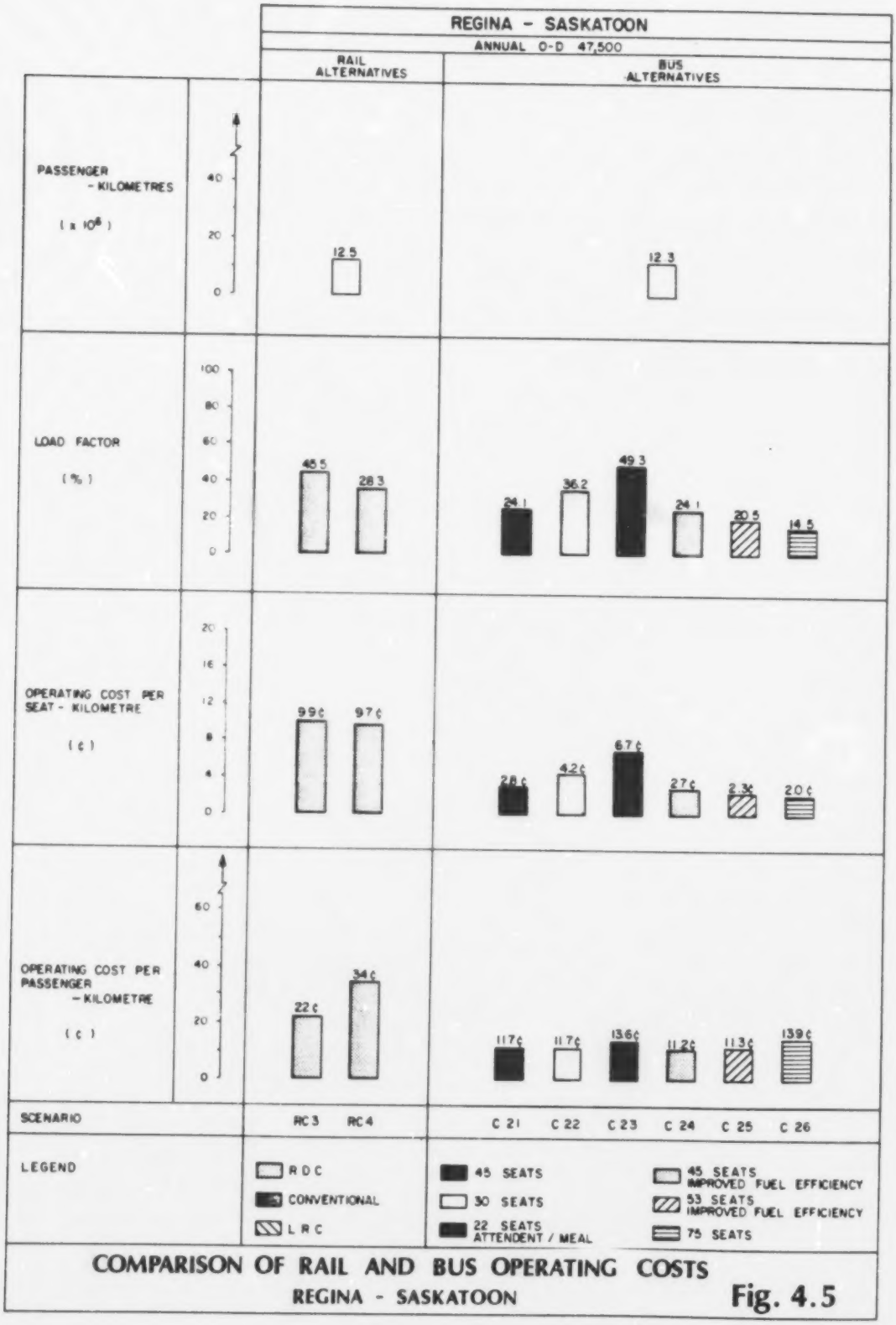
COMPARISON OF RAIL AND BUS OPERATING COSTS
WINNIPEG - THOMPSON

Fig. 4.3



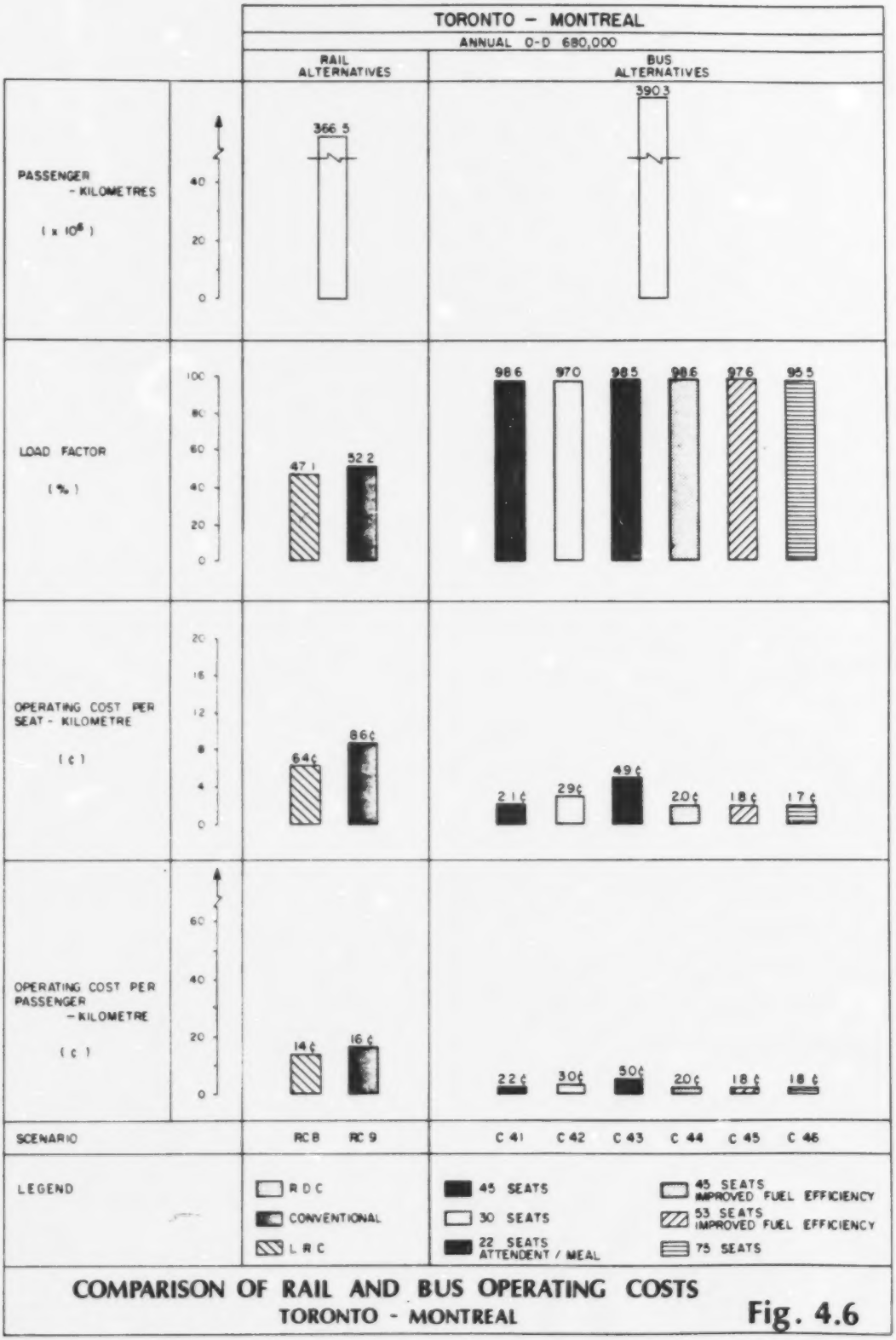
COMPARISON OF RAIL AND BUS OPERATING COSTS
WINNIPEG - EDMONTON

Fig. 4.4



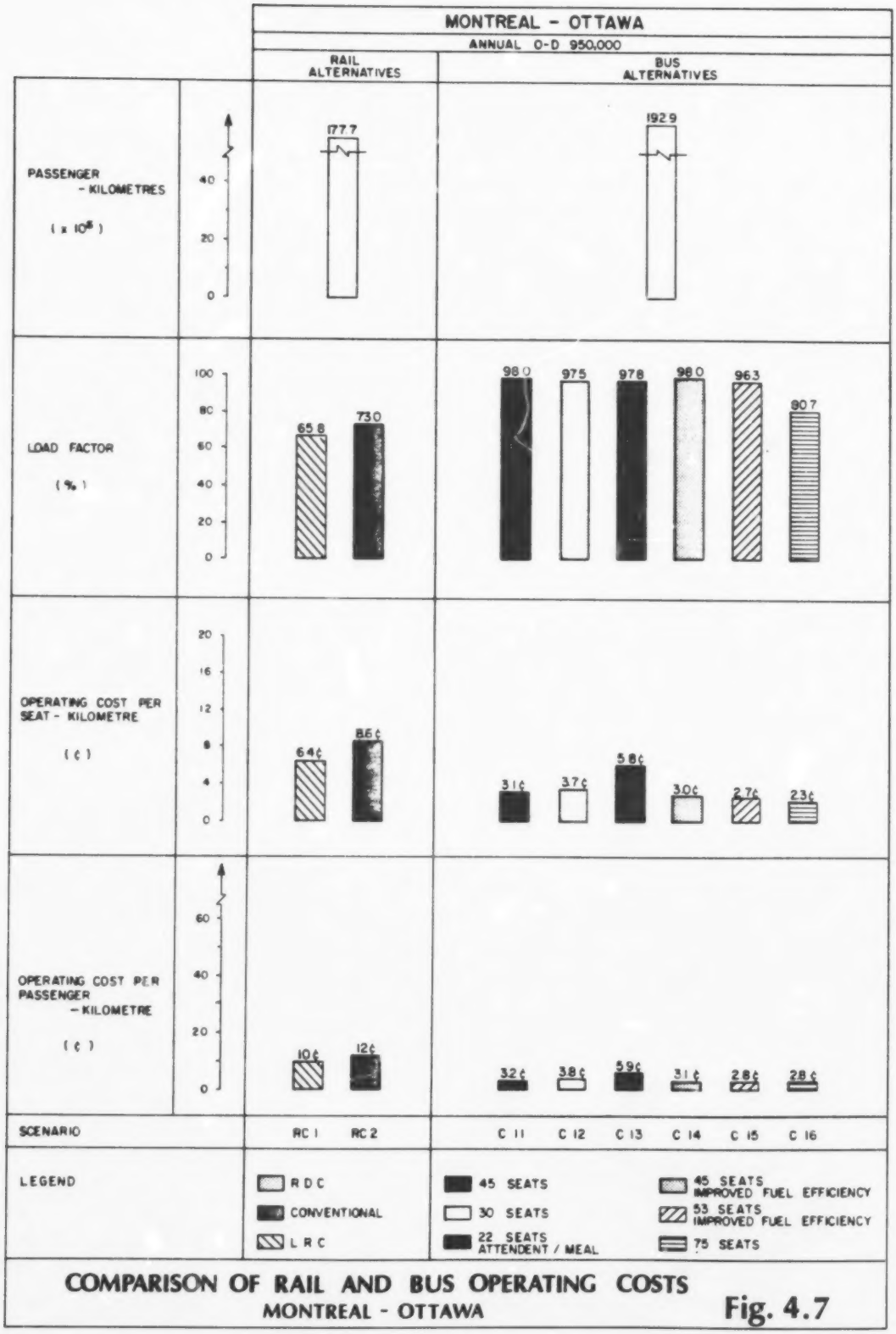
COMPARISON OF RAIL AND BUS OPERATING COSTS
REGINA - SASKATOON

Fig. 4.5



COMPARISON OF RAIL AND BUS OPERATING COSTS
TORONTO - MONTREAL

Fig. 4.6



COMPARISON OF RAIL AND BUS OPERATING COSTS
MONTREAL - OTTAWA

Fig. 4.7

5. CONCLUSIONS

Rail

- The study confirms the most appropriate application of LRC equipment to be high density, short haul routes; of RDC equipment to be low density routes; and of conventional rail equipment to be overnight routes.

- The operating costs exhibited by LRC's are lowest. Those of RDC's are slightly higher. Highest costs are demonstrated by conventional rail equipment.

Bus

- The study confirms that significant economic savings can be achieved via a reduction in fuel consumption. Accordingly it is recommended that efforts should be directed towards the development of improved fuel efficient engines.

- It is concluded that there is a market for slightly larger buses (i.e. 53 seaters) and that the use of such vehicles on high density routes can reduce overall operating costs.

- A cost advantage may be achieved by operating reduced capacity vehicles which provide more space, comfort and possibly on-board meal services, on lower density routes provided that complementary marketing efforts are initiated.

Rail Bus

- It is concluded that rail is the more expensive of the two modes -regardless of route, service frequency or ridership.

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2

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Study of Intercity Surface Transportation Alternatives

Summary Report

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STUDY OF INTERCITY

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FOR

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

JULY 1984

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17. Abstract

While almost all modes of intercity passenger transportation in Canada involve some degree of public subsidy, rail passenger services represent a particularly serious financial burden, especially since on many routes the bus offers service faster and more frequent than that of the train. This study was initiated in response to such concerns. Its objective was to identify, based on cost performance, the most appropriate applications for each of these two modes within the intercity passenger transportation system. Cost models were developed by correlating key performance variables with cost accounting data. The rail cost model covers three types of equipment currently in service; the bus cost model is based on data for a standard 40 ft. (12 m) coach, but also allows for the consideration of high-capacity buses and innovative types of service with a level of comfort equivalent to that of a train. The models were applied to seven Canadian routes of various lengths (200 to 1350 km) and passenger densities. In all cases the cost of rail service was substantially greater than that of bus service. In a comparison of scenarios in which either rail or bus carries all the surface mode passengers, rail costs were estimated at 6.4 to 16.3¢/seat-km, bus costs at 1.7 to 6.7¢/seat-km.

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17. Résumé

Bien que presque tous les modes de transport interville de personnes au Canada doivent être subventionnés d'une manière ou d'une autre, il s'avère que le transport ferroviaire de personnes constitue une charge financière particulièrement lourde, surtout que sur bon nombre des liaisons actuelles, l'autobus pourrait offrir un service plus rapide et plus fréquent. L'étude dont le présent rapport rend compte a été lancée afin d'approfondir cette question; son but était de rechercher les liaisons types pour la desserte desquelles ces deux modes de transport sont le mieux adaptés, le critère retenu étant le coût du transport. Des modèles de coût ont été élaborés, mettant en corrélation les principaux paramètres de fonctionnement, d'une part, et de coût, d'autre part. Le modèle relatif au transport ferroviaire a pris en compte trois matériels couramment en service; celui du transport routier a été fondé sur l'autocar classique de 40 pieds (12 m), mais permet aussi de considérer des nouveaux matériels grande capacité et des services novateurs offrant un confort comparable à celui du train. Les modèles en question ont été appliqués à sept itinéraires canadiens différenciés par la distance totale (entre 200 et 1 350 km) et le volume de la clientèle. Il a été constaté que, dans tous les cas étudiés, le coût du transport ferroviaire était sensiblement supérieur à celui de l'autobus. En situation de monopole, c'est-à-dire un scénario où les voyageurs empruntant un mode de surface seraient tous transportés par train, ou par autobus, il a été trouvé que la place-kilomètre coûterait entre 6,4 et 16,3¢ dans le cas du train, et entre 1,7 et 6,7¢ dans le cas de l'autobus.

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STUDY OF INTERCITY SURFACE TRANSPORTATION ALTERNATIVES

1. INTRODUCTION

While almost all forms of intercity passenger transportation in Canada involve some degree of public subsidy, there is a general perception that rail passenger services represent a significant financial burden to the federal government and that, of the routes served by the rail system, many are also served by buses which offer service frequency and speed superior to that of the train.

In response to such concerns, the Transportation Development Centre, Transport Canada, initiated a study to develop rail and bus cost models by which to identify the most appropriate applications for rail and bus services within the intercity passenger transportation system. Traditional buses, high capacity buses and also innovative types of bus service which provide an equivalent service to rail in terms of comfort and space were considered.

Marshall Macklin Monaghan Limited was retained as prime consultant, to carry out the assignment.

2. DESCRIPTION OF THE COST MODELS

2.1 The Rail Cost Model

The rail cost model is an interactive computer program comprising four major sections:

- o INPUT - which accepts the route specific input data and computes various operating variables including car-kilometres, seat-kilometres and passenger-kilometres.
- o AVERAGE OPERATING COST CALCULATIONS - which compute refined estimates of specific operating costs and generates annualized capital costs of rolling stock.
- o PERFORMANCE MEASURES - which tabulate the costs computed previously by functional group.

For convenience the cost functions are addressed under two major headings; basic operating costs and unit capital costs.

2.1.1 - Basic Operating Costs

Operating cost functions, determined using information obtained from the Canadian Transport Commission and other published documents, include:

- o Train Operations, which includes maintenance of rolling stock, crew wages and fuel.

- o Track Related Operations, which includes maintenance of way, train control and switching, line haul and communications costs.

- o Other Services, which include on-board and station service costs. Both these functions can generate revenue through charges other than ticket prices.

- o Overhead, which includes marketing, reservations and general administration as the major items.

Presented in Table 2.1 are the unit operating costs by service (high density, low density and overnight) with which the model has been programmed.

The reasonableness of these estimates has been determined, in general terms, by comparing them against other available rail cost data.

These unit values constitute the basic operating parameters of the rail passenger cost model. The user may either adopt these values or resort to specific independent inputs.

TABLE 2.1

PASSENGER RAIL OPERATING COSTS BY TYPE OF SERVICE (1983 $)

	Cost Per Car - Kilometre		
	High Density	Low Density	Overnight
Train Operations			
Equipment Maintenance	1.00	2.10	1.20
Train Crew	0.40	1.50	0.40
Line Haul Fuel	0.20	0.30	0.10
Track Related Operations	0.40	0.50	0.30
Other Services			
On-Board Services	0.30	0.30	0.30
Station Services	0.30	0.20	0.70
Overhead			
Marketing and Reservations	0.10	0.10	0.10
General Administration	0.50	1.00	0.60

It was deemed more appropriate to develop alternate unit values and procedures by which to estimate the cost of equipment maintenance, crew costs and fuel costs for individual types of equipment (RDC, LRC and conventional), rather than to rely solely on system wide averages. Additional values and routines, with which the model has been programmed, are presented in the following paragraphs.

a) Equipment Maintenance

The model is equipped with the following set of default unit values which are representative of the maintenance costs by individual type of equipment.

Conventional	-	$1.70 per locomotive kilometre
	-	$0.90 per coach kilometre
RDC	-	$2.50 per power unit kilometre
	-	$2.00 per additional unit kilometre
LRC	-	$2.25 per locomotive kilometre
	-	$1.15 per coach kilometre

b) Crew Costs

The cost model is equipped with two procedures by which to estimate crew costs. The first is a "distance based" formula. The second is based on an hourly wage. The user may select from either of these procedures, from the values presented in Table 2.1 or resort to specific independent inputs.

Presented below is the "distance based" formula commonly accepted in the rail industry.

$$Cc = \sum_{i=1}^{n} (a_i x_i) \cdot \frac{f}{y \cdot d \cdot c}$$

where:

Cc	=	annual crew cost per car-kilometre
a_i	=	annual salary of crew member of type i
x_i	=	number of crew members of type i
f	=	fringe, overhead, layover cost factor
y	=	number of working days in a year
d	=	distance that defines a day's work
c	=	number of coaches in the consist

Values to which the model will default are f = 1.20; y = 250; and d = 150 km.

The user may select the size of crew or may resort to the following default values. RDC consists - 2 members. LRC consists - 3 members and conventional consists - 4 members. The average annual salary per crew member is assumed by the model to be $40 000.00.

The second procedure that can be used for the calculation of crew costs is based on an hourly wage. In this case, the general formula for unit crew costs (Cc) is expressed as follows:

$$Cc = \sum_{i=1}^{n} (w_i x_i) \cdot \frac{f \cdot g}{s}$$

where:

w_i = hourly wage of crew member of type i
x_i = number of crew members of type i
f = fringe, overhead, layover cost factor
g = delay, additional dead heading cost factor
s = average operating speed

The default values which have been adopted are an average hourly wage of $20.00 per hour, an operating speed of 80 km per hour and values of 1.2 and 1.5 for f and g, respectively. Default crew sizes are the same as those set by the distance based formula.

c) Fuel Costs

Unit fuel costs vary considerably with type of equipment, as well as consist configuration. Default values with which the program is equipped are listed below:

o	RDC	-	power unit	$0.25 per kilometre
		-	trailing coach	$0.15 per kilometre
o	LRC	-	locomotive	$0.35 per kilometre
		-	trailing coach	$0.02 per kilometre
o	Conventional	-	locomotive	$0.40 per kilometre
		-	coach	$0.05 per kilometre

2.1.2 - Unit Capital Costs

Capital costs of rolling stock, such as locomotives and passenger coaches, are included in the model. Capital costs associated with fixed plant facilities are excluded.

Capital costs are annualized by means of the following formula:

$$C_i = CRF_i (r, n) \cdot PV_i \cdot NV_i$$

where **C** represents the annual cost of coach or locomotive type **i**; **PV** represents the price of vehicle type **i**; **NV** the number of vehicles of that type; and **CRF** the capital recovery factor which is a function of the operating cost of capital **r** and the vehicle life **n**.

Even though the model is capable of responding to specific user inputs, it is equipped with the following standard set of default vehicle prices:

	Price $ Millions
RDC Coach	1.0
LRC Locomotive	1.6
LRC Coach	0.6
Conventional Locomotive	1.2
Conventional Coach	0.3

The operating cost of capital is set at five (5) percent per annum over a vehicle life of 15 years.

The annual costs derived by application of the abovementioned equation are converted to unit costs on the basis of utilization rates (ie., vehicle kilometres). These vehicle unit costs can be combined to yield train unit costs for specific consist configurations.

2.2 The Bus Cost Model

The bus cost model consists of the following four interconnected computer programs:

- **INPUT** - which accepts the route specific input data required by the model and stores the information in computer files. If detailed schedule and demand data is unknown the program will synthesize a schedule and demand pattern based on user supplied aggregate information.

- **BUS 1,** which uses a simplified algorithm designed specifically for this project to compute the minimum number of buses required to execute the schedule defined by INPUT. It also calculates all vehicle related and passenger related output measures (i.e., vehicle - kilometres, passenger - kilometres etc.) required to compute the route operating costs.

- **BUS 2,** which estimates the number of drivers required based on the schedule defined by INPUT.

- **COST 1,** which computes the route costs by cost account given the output measures computed by BUS 1 and BUS 2.

The following unit cost categories were adopted by the bus cost model:

- **Driver Expenses,** which include driver wages, benefits and travel expenses.

- **Vehicle Expenses,** which include fuel, fuel taxes, operating supplies, depreciation, licenses, insurance, road fees and tolls.

- **In-Vehicle Service Expenses,** which include attendant related expenses (i.e., wages and benefits) and service supplies (i.e., food, magazines, etc.).

- **Terminal Expenses,** which include ticket cost, agent's commission and all other terminal related expenses which must be paid by the various operators having access to the terminal.

- **Maintenance Expenses,** which include salaries and benefits, vehicle repair and repair of in-vehicle service facilities.

- **Administrative and General Expenses** which include advertising, marketing and administration.

Table 2.2 presents the unit cost estimates for **a conventional 45-passenger MCI bus,** categorized as elements of the six major cost accounts. **These values constitute the basic parameters of the bus passenger cost model.** As in the case of the rail model the user may adopt these values or resort to independent input.

In-vehicle service expenses are non relevant in the case of the conventional MCI bus. Accordingly, they are defined as such. The I's in the table indicate rates which are calculated internally within the cost model as a function of more fundamental user-supplied data. For example, the vehicle fleet depreciation rate is a function of the capital cost of the vehicle, the vehicle's economic life, and the interest rate which for the purpose of this study are set at the following values:

o Capital cost of an MCI vehicle	$ 200 000.00
o Vehicle life	10 Years
o Annual Cost of Capital	5 percent
o Vehicle salvage value	$ 500.00

TABLE 2.2

ESTIMATED 1983 BUS UNIT COSTS FOR
A CONVENTIONAL 45 PASSENGER MCI BUS

COST ACCOUNT	UNIT COST*	OUTPUT UNIT
Driver Expenses		
Driver Wages	I	Driver hours
Driver Benefits	20.8%	% of salaries
Driver Travel Expenses	I	Calculated directly
Vehicle Expenses		
Fuel (including tax)	14.0	Vehicle-kilometres
Other Operating Supplies	2.9	Vehicle-kilometres
Vehicle Fleet Depreciation	I	Vehicles
Vehicle Licenses	0.6	Vehicle-kilometres
Vehicle Insurance	1.1	Vehicle-kilometres
Road Fees and Tolls	0.5	Vehicle-kilometres
In-Vehicle Service Expenses		
In-Vehicle Attendants' Wages, Benefits, Travel Expenses	N/A	Vehicle-hours
In-Vehicle Service Supplies (Food, Magazines, etc.)	N/A	Passenger-hours
Terminal Expenses		
Ticket Costs	9.6	Passengers
Agents' Commission	75.2	Passengers
Terminal Operations	81.8	Passengers
Maintenance Expenses		
Salaries	8.9	Vehicle-kilometres
Benefits	20.8%	% of salaries
Vehicle Repair	15.4	Vehicle-kilometres
Repair of In-Vehicle Service Facilities	N/A	Vehicle-kilometres
Administrative & General Expenses		
Advertising/Marketing	2.8	Vehicle-kilometres
Administration Expenses	14.2	Vehicle-kilometres

Legend:
I: Internally calculated within the model
N/A: Not applicable
* Cents per unit output, except for benefits

3. APPLICATION OF THE COST MODELS

3.1 Application of the Rail Cost Model

The following combinations of service and rolling stock were selected for this demonstration.

RDC
- o Low density
- o Low density including modified snack bar
- o High density including modified snack bar

Conventional
- o Low density
- o Low density overniter
- o High density

LRC
- o High density

A general comparison of the equipment specific costs is presented in Figure 3.1 in terms of the cost per seat-kilometre (i.e., implicity assumes a load factor equal to 100 percent).

TABLE 3.1

EQUIPMENT SPECIFIC COSTS COMPARISON

	Cents Per Seat-Kilometre		
	Low Density	High Density	Overnight
Conventional	16.3	8.6 -9.6	14.6 -15.1
RDC	9.7 - 9.9	8.9	N/A
LRC	N/A	6.4 -7.1	N/A

On high density routes, LRC's exhibit the lowest operating costs. RDC's exhibit the lowest operating costs on the low density routes. These results conform to the design and current use of such equipment.

Routes selected for this demonstration are presented in Table 3.2.

Presented in Figure 3.1 are the results expressed in terms of unit operating costs per seat-kilometre and per passenger-kilometre.

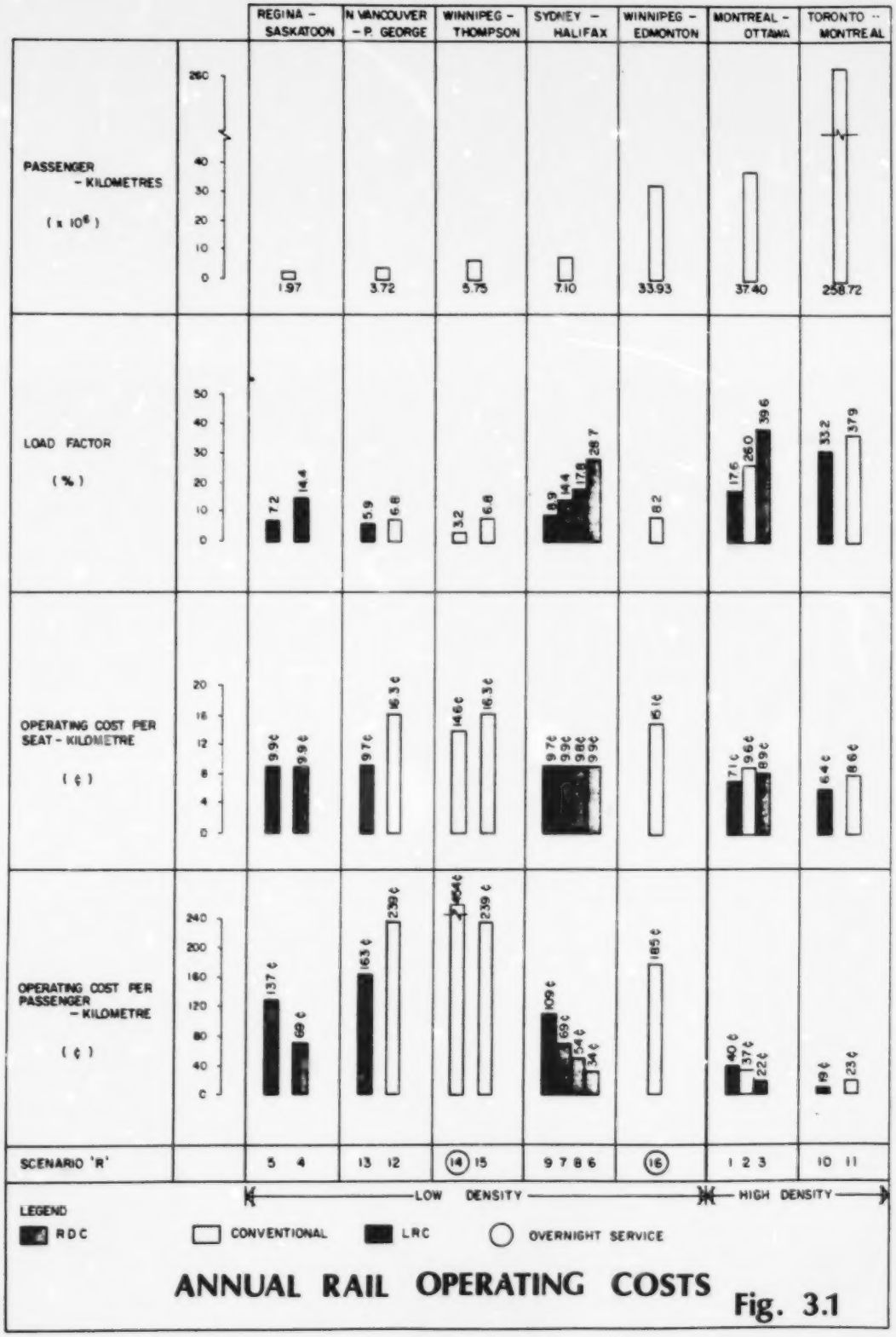
TABLE 3.2
ROUTE SPECIFIC RAIL SCENARIOS

Route	Scenario	Dist. (km)	Annual O-D	Daily Freq. (2-way)	Equipment and Consist (Typical)	Cars Per Train	Seats Per Train
Montreal - Ottawa*	R1	187	200 000	12	LRC: 1PV + 3C + 1CL	5	280
	R2		200 000	12	CONV: 1PV + 2C + 1CL + 1D	5	189
	R3		200 000	12	RDC: RDC + MSB	2	124
Regina - Saskatchewan	R4	263	7 500	2	RDC: RDC	1	77
	R5		7 500	4	RDC: RDC	1	77
Sydney - Halifax **	R6	473	15 000	2	RDC: RDC	1	77
	R7		15 000	4	RDC: RDC	1	77
	R8		15 000	2	RDC: RDC + MSB	2	124
	R9		15 000	4	TDC: RDC + MSB	2	124
Toronto - Montreal	R10	539	480 000	12	LRC: 1PV + 4C + 1CL	6	354
	R11		480 000	12	CONV: 2PV + 3C + 1CL + 1DN + 1	8	320
N. Vancouver - P. George**	R12	744	5 000	2	CONV: 1PV + 1C + 1CL + 1	4	108
	R13		5 000	2	RDC: RDC + MSB	2	124
Winnipeg - Thompson***	R14	1 149	5 000	2	CONV: 1PV + 2C + 2S +1CL + 2D + 1	9	228
	R15		5 000	2	CONV: 1PV + 1C + 1CL + 1	4	108
Winnipeg - Edmonton***	R16	1 357	25 000	2	CONV: 3PV + 3C + 2DN + 67S + 4	18	416

Legend

PV - Power Unit C - Coach CL - Club Car DN - Dayniter D - Dinette MSB - Modified Snack Bar S - Sleeper

* High Density ** Low Density *** Overniter



ANNUAL RAIL OPERATING COSTS **Fig. 3.1**

3.2 Application of the Bus Cost Model

The bus cost model was applied to six bus scenarios. They are presented below categorized as either conventional technology; conventional buses with innovative on-board attributes which provide an equivalent service to rail in terms of comfort, space and on-board services; and high capacity buses and technological alternatives to the conventional bus which are considered feasible in the short term.

	Category	Scenario	Description
o	Conventional Bus	1	- 40' Bus, 45 Seats
o	Conventional Buses with Innovative On-Board Attributes	2	- 40' Bus, 30 Seats
		3	- 40' Bus, 22 Seats On Board Attendant On Board Meal Service
o	High Capacity Buses & Technological Alternatives	4	- 40' Bus, 45 Seats Improved Fuel Efficiency
		5	- 45' Bus, 53 Seats Improved Fuel Efficiency
		6	- High Capacity Bus, 75 Seats

The conventional bus is twelve metres long (40 feet) and seats 45 passengers. Service alternatives considered include the conventional bus with a reduced capacity of 30 seats and the conventional bus with a reduced capacity of 22 seats plus on-board attendant and meal service.

Technological alternatives to the conventional bus which are considered feasible are a bus of the same size and seating capacity equipped with an improved fuel efficient engine; a slightly larger bus (45 feet) with a capacity of 53 seats equipped with a fuel efficient engine; and a high capacity bus (either articulated or double decker) with approximately 75 seats.

Presented in Table 3.3 are the factors selected to convert the conventional MCI bus unit cost accounts (presented in Table 2.2) to specific unit costs representative of the individual types of service and technology for each of the scenarios considered by this demonstration.

Presented in Table 3.4 is a summary of annual operations and the corresponding costs generated by the bus model.

TABLE 3.3

ESTIMATED CHANGES IN BUS UNIT COSTS
FOR NON-CONVENTIONAL BUSES

	SCENARIO					
	Conv. 40' Bus	Conventional 40' Bus with Service Alternatives		Technological Alternatives		
COST ACCOUNT	45 Seats	30 Seats	22 Seats Att./Meals	40' Bus 45 Seats Inc. Fuel Efficiency	45' Bus 53 Seats Inc. Fuel Efficiency	High Capacity Bus 75 Seats
Wages - Driver	o	o	o	o	o	+ 10%
- Attendant	-	-	$10/veh-hr	-	-	-
Fuel	o	o	o	- 40%	- 40%	+ 30%
Op. Supplies	o	o	o	o	o	+ 40%
Food/Beverage	-	-	$0.50/pass-hr	-	-	-
License	o	o	o	o	+ 10%	+ 40%
Insurance	o	o	o	o	+ 10%	+ 100%
Maintenance						
- Salaries	o	o	o	o	o	+ 40%
- Supplies	o	o	o	o	o	+ 40%
Capital Cost	o	o	+ 5%	+ 5%	+ 10%	+ 60%

Legend - Not applicable

o Base case or no change from base

TABLE 3.4
SUMMARY OF ANNUAL BUS OPERATIONS AND COSTS

	Link	Scen.	Daily Dep.	Veh. -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Pass. Per Bus	Load Factor (%)	$Mill.	$Per Veh. -Km	¢Per Seat -Km	¢Per Pass. -Km
1.	Montreal - Ottawa	B11	47	3 482	156 711	152 250	44	97.2	4.86	1.40	3.1	3.2
		B12	71	5 261	157 822	152 250	29	96.5	6.71	1.28	4.3	4.4
		B13	95	7 039	154 859	152 250	22	98.3	9.10	1.29	5.9	6.0
		B14	47	3 482	156 711	152 250	44	97.2	4.68	1.34	3.0	3.1
		B15	43	3 186	168 863	152 250	48	90.2	4.35	1.37	2.6	2.9
		B16	43	3 186	238 956	152 250	48	63.7	5.09	1.60	2.1	3.3
2.	Regina - Saskatoon	B21	12	1 134	51 049	10 360	9	20.3	1.43	1.26	2.8	13.8
		B22	12	1 134	34 033	10 360	9	30.4	1.43	1.26	4.2	13.8
		B23	12	1 134	24 957	10 360	9	41.5	1.65	1.46	6.6	15.9
		B24	12	1 134	51 049	10 360	9	20.3	1.37	1.21	2.5	13.2
		B25	12	1 134	60 124	10 360	9	17.2	1.38	1.22	2.3	13.3
		B26	12	1 134	85 082	10 360	9	12.2	1.69	1.49	2.0	16.3
3.	Sydney - Halifax	B31	6	985	44 348	2 250	2	5.1	1.15	1.17	2.6	51.1
		B32	6	985	29 565	2 250	2	7.6	1.15	1.17	3.9	51.1
		B33	6	985	21 681	2 250	2	10.4	1.32	1.34	6.1	58.7
		B34	6	985	44 348	2 250	2	5.1	1.10	1.12	2.5	48.9
		B35	6	985	52 232	2 250	2	4.3	1.11	1.13	2.1	49.3
		B36	6	985	73 913	2 250	2	3.0	1.39	1.41	1.9	61.8
4.	Toronto - Montreal	B41	14	2 933	131 991	114 800	39	87.0	3.51	1.20	2.7	3.1
		B42	20	4 190	125 706	114 800	27	91.3	4.94	1.18	3.9	4.3
		B43	26	5 447	119 840	114 800	21	95.8	6.54	1.20	5.5	5.7
		B44	14	2 933	131 991	114 800	39	87.0	3.36	1.15	2.5	2.9
		B45	12	2 514	133 248	114 800	46	86.2	2.94	1.17	2.2	2.6
		B46	12	2 514	188 559	114 800	46	60.9	3.55	1.41	1.9	3.1

TABLE 3.4
SUMMARY OF ANNUAL BUS OPERATIONS AND COSTS
(Continued)

	Link	Scen.	Daily Dep.	Veh. -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Pass. Per Bus	Load Factor (%)	$Mill.	$Per Veh. -Km	¢Per Seat -Km	¢Per Pass. -Km
5.	N. Vancouver	B51	6	1 763	79 333	8 050	5	10.1	1.98	1.12	2.5	24.6
	- P. George	B52	6	1 763	52 889	8 050	5	15.2	1.98	1.12	3.7	24.6
		B53	6	1 763	38 785	8 050	5	20.8	2.34	1.33	6.0	29.1
		B54	6	1 763	79 333	8 050	5	10.1	1.89	1.07	2.4	23.5
		B55	6	1 763	93 436	8 050	5	8.6	1.90	1.08	2.0	23.6
		B56	6	1 763	132 221	8 050	5	6.1	2.33	1.32	1.8	28.9
6.	Winnipeg	B61	4	959	43 156	15 320	16	35.5	1.09	1.14	2.5	7.1
	- Thompson	B62	4	959	28 771	15 320	16	53.2	1.09	1.14	3.8	7.1
		B63	4	959	21 099	15 320	16	72.6	1.32	1.38	6.3	8.6
		B64	4	959	43 156	15 320	16	35.5	1.04	1.08	2.4	6.8
		B65	4	959	50 829	15 320	16	30.1	1.05	1.09	2.1	6.9
		B66	4	959	71 927	15 320	16	21.3	1.29	1.35	1.8	8.4
7.	Winnipeg	B71	6	2 930	131 860	6 690	2	5.1	3.16	1.08	2.4	47.2
	- Edmonton	B72	6	2 930	87 907	6 690	2	7.6	3.16	1.08	3.6	47.2
		B73	6	2 930	64 465	6 690	2	10.4	3.64	1.24	5.6	54.4
		B74	6	2 930	131 860	6 690	2	5.1	3.00	1.02	2.3	44.8
		B75	6	2 930	155 302	6 690	2	4.3	3.02	1.03	1.9	45.1
		B76	6	2 930	219 767	6 690	2	3.0	3.69	1.26	1.7	55.2

Key results are illustrated graphically in Figure 3.2 and are summarized below:

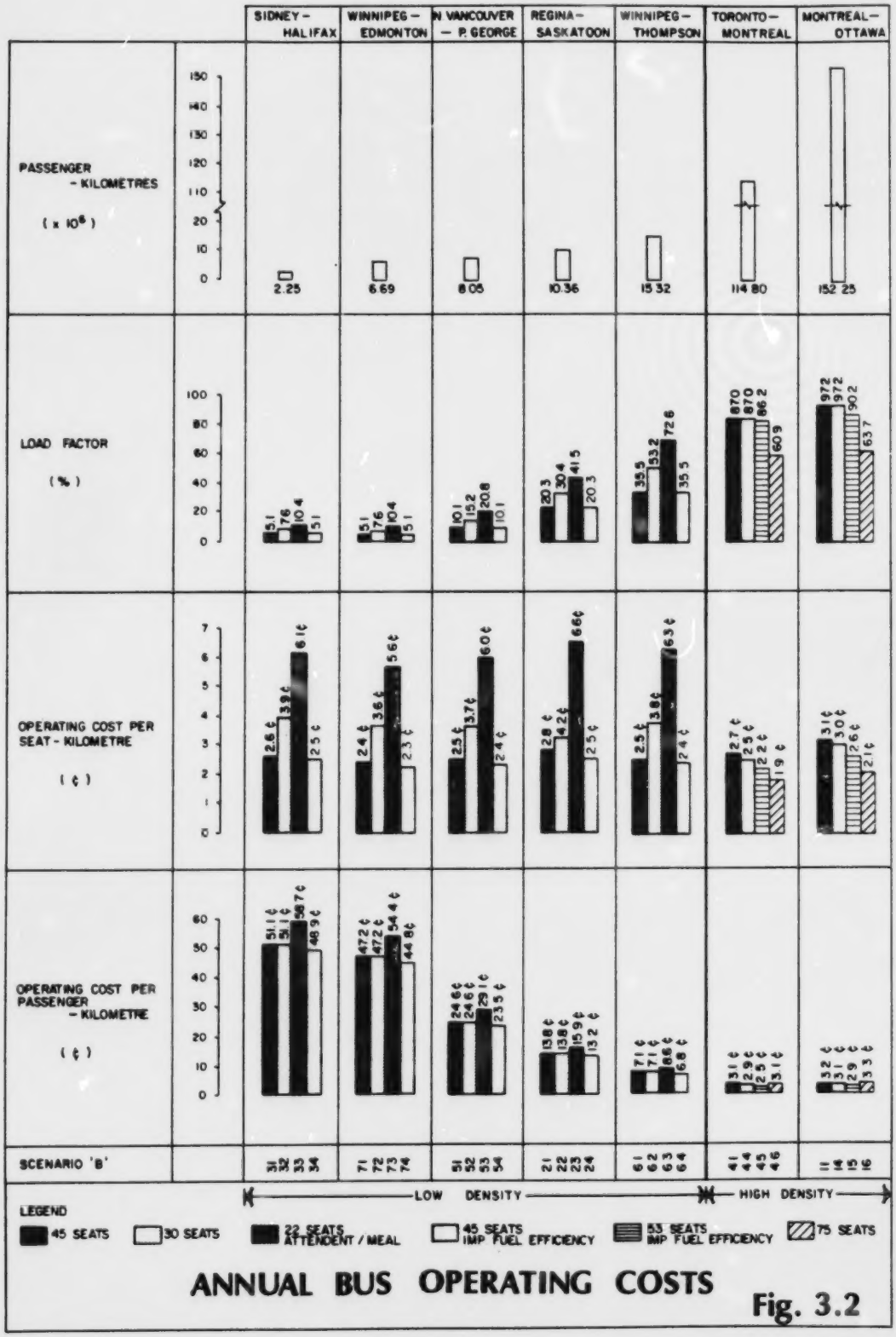
- Of the six scenarios tested, Scenario 4, a fuel efficient bus (45 seats) and Scenario 5, a slightly longer, fuel efficient bus (53 seats) consistently exhibit the lowest operating costs per passenger-kilometre.

- Scenario 4 exhibits the lower of the two sets of values on low density routes, while Scenario 5 exhibits the lower values on high density routes.

- These results suggest that a significant improvement in cost performance can be derived by directing efforts towards the development of improved fuel efficient engines.

- These results also imply that there is an additional marginal benefit to be gained by the operation of slightly longer buses (53 seats) on high density routes.

- Although not shown by the results presented in Table 3.4, there can be a cost advantage associated with the operation of either a 30-seat or a 22-seat bus on low density routes provided that the operator initiates a marketing effort (to advertise the additional space and on-board service in the case of a 22-seat bus) directed to the attraction of additional riders.



ANNUAL BUS OPERATING COSTS

Fig. 3.2

4. COMPARISON OF RAIL/BUS ALTERNATIVES

In Section 3.1, rail costs were estimated on the basis of existing rail passenger flows and a comparison was made among the rail alternatives in order to evaluate the comparative "within mode" advantages of various rail technologies.

In Section 3.2, bus costs were estimated on the basis of existing bus passenger flows and a similar comparison was made among the bus alternatives addressing the comparative advantages of the various bus technologies and services considered.

In this chapter, rail and bus costs are determined for equal passenger flows. Comparisons of cost performance are made in terms of both unit and total costs.

Presented in Table 4.1 are the rail alternatives selected for this segment of the study.

Annual operating costs, expressed in terms of total and unit values, are presented in Table 4.2.

All six of the bus scenarios described previously were tested on each of the study routes. Presented in Table 4.3 are the operational and cost performances exhibited.

Presented in the following figures are the key performance and unit costs generated by the rail and bus models for each of the scenarios considered. The results are presented by route. The North Vancouver-Prince George run, bearing the lowest passenger flow assignment (15 000 passengers per annum) is addressed first (Figure 4.1). Each of the other runs is subsequently addressed, in turn, according to increasing passenger flow assignments. The Montreal-Ottawa run, bearing the highest value (950 000 passengers per annum) is shown last (Figure 4.7).

TABLE 4.1
RAIL SCENARIOS SELECTED FOR RAIL/BUS COMPARISONS

	City - Pair	Scenario	Annual O-D	Daily Freq. (2-way)	Equipment and Consist (Typical)	Cars Per Train	Seats Per Train
1.	Montreal - Ottawa	RC1	950 000	12	LRC: 1PV + 4C + 1CL	6	354
		RC2	950 000	12	CONV: 2PV + 4C + 1CL + 1D	8	320
2.	Regina - Saskatoon	RC3	47 500	4	RDC: 1RDC	1	77
		RC4	47 500	4	RDC: RDC + MSB	2	124
3.	Sydney - Halifax	RC5	20 000	4	RDC: 1RDC	1	77
		RC6	20 000	2	RDC: RDC + MSB	2	124
		RC7	20 000	4	RDC: RDC + MSB	2	124
4.	Toronto - Montreal	RC8	680 000	12	LRC: 1PV + 4C + 1CL	6	354
		RC9	680 000	12	CONV: 2PV + 3C + 1CL + 1DN + 1	8	320
5.	N. Vancouver - P. George	RC10	15 000	2	CONV: 1PV + 1C + 1CL + 1	4	108
		RC11	15 000	2	RDC: RDC + MSB	2	124
6.	Winnipeg - Thompson	RC12	25 000	2	CONV: 1PV + 2C + 2S + 1CL + 2D + 1	9	228
		RC13	25 000	2	CONV: 1 PV + 1C + 1CL + 1	4	108
7.	Winnipeg - Edmonton	RC14	30 000	2	CONV: 3PV + 3C + 2DN + 6S + 4	18	416

Legend

PV - Power Unit C - Coach CL - Club Car DN - Dayniter D - Dinette MSB - Modified Snack Bar
S - Sleeper

TABLE 4.2
ANNUAL OPERATING COSTS OF RAIL ALTERNATIVES

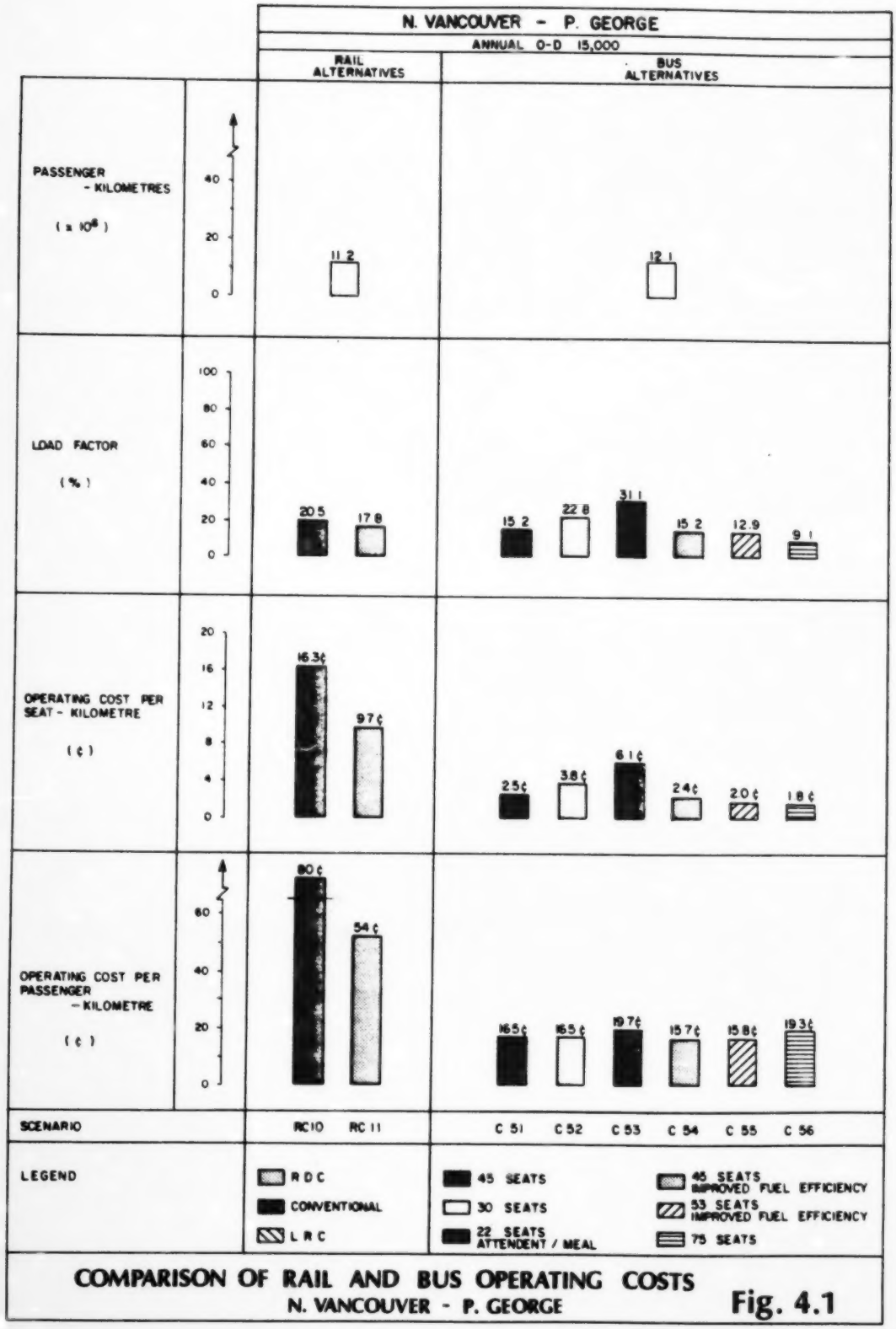
Link	Scen.	Equip.	$ Millions	$ Per Train -Km	$ Per Car -Km	¢ Per Seat -Km	¢ Per Pass. -Km
1. Montreal - Ottawa	RC1	LRC	17.33	22.77	3.79	6.4	10
	RC2	CONV.	20.81	27.35	3.42	8.6	12
2. Regina - Saskatoon	RC3	RDC	2.71	7.59	7.59	9.9	22
	RC4	RDC	4.30	12.04	6.03	9.7	34
3. Sydney - Halifax	RC5	RDC	4.88	7.61	7.61	9.9	52
	RC6	RDC	3.86	12.02	6.02	9.7	41
	RC7	RDC	7.73	12.06	6.02	9.7	82
4. Toronto - Montreal	RC8	LRC	49.94	22.77	3.80	6.4	14
	RC9	CONV.	59.97	27.35	3.42	8.6	16
5. N. Vancouver - P. George	RC10	CONV.	8.88	17.62	4.40	16.3	80
	RC11	RDC	6.08	12.06	6.03	9.7	54
6. Winnipeg - Thompson	RC12	CONV.	26.11	33.52	3.72	14.6	91
	RC13	CONV.	13.71	17.60	4.40	16.3	48
7. Winnipeg - Edmonton	RC14	CONV.	62.64	63.21	3.51	15.1	154

TABLE 4.3
OPERATIONAL AND COST PERFORMANCE OF BUS ALTERNATIVES

	Link	Scen.	Daily Dep.	Veh. -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Pass. Per Bus	Load Factor (%)	$Mill.	$Per Veh. -Km	¢Per Seat -Km	¢Per Pass. -Km
1.	Montreal - Ottawa	C11	59	4 372	196 722	192 850	44	98.0	6.15	1.41	3.1	3.2
		C12	89	6 594	197 834	192 850	29	97.5	7.35	1.11	3.7	3.8
		C13	121	8 965	197 241	192 850	22	97.8	11.46	1.28	5.8	5.9
		C14	59	4 372	196 722	192 850	44	98.0	5.93	1.36	3.0	3.1
		C15	51	3 779	200 279	192 850	51	96.3	5.35	1.42	2.7	2.8
		C16	43	3 186	238 956	192 850	61	80.7	5.42	1.70	2.3	2.8
2.	Regina - Saskatoon	C21	12	1 134	51 049	12 303	11	24.1	1.44	1.27	2.8	11.7
		C22	12	1 134	34 033	12 303	11	36.2	1.44	1.27	4.2	11.7
		C23	12	1 134	24 957	12 303	11	49.3	1.67	1.47	6.7	13.6
		C24	12	1 134	51 049	12 303	11	24.1	1.38	1.22	2.7	11.2
		C25	12	1 134	60 124	12 303	11	20.5	1.39	1.23	2.3	11.3
		C26	12	1 134	85 082	12 303	11	14.5	1.71	1.51	2.0	13.9
3.	Sydney - Halifax	C31	6	986	44 348	9 000	9	20.3	1.17	1.19	2.6	13.0
		C32	6	986	29 565	9 000	9	30.4	1.17	1.19	4.0	13.0
		C33	6	986	21 681	9 000	9	41.5	1.39	1.41	6.4	15.4
		C34	6	986	44 348	9 000	9	20.3	1.13	1.15	2.5	12.6
		C35	6	986	52 232	9 000	9	17.2	1.13	1.15	2.2	12.6
		C36	6	986	73 913	9 000	9	12.2	1.41	1.43	1.9	15.7
4.	Toronto - Montreal	C41	42	8 799	395 974	390 320	44	98.6	8.40	0.95	2.1	2.2
		C42	64	13 409	402 259	390 320	29	97.0	11.69	0.87	2.9	3.0
		C43	86	18 018	396 393	390 320	22	98.5	19.38	1.08	4.9	5.0
		C44	42	8 799	395 974	390 320	44	98.6	7.94	0.90	2.0	2.0
		C45	36	7 542	399 745	390 320	52	97.6	7.14	0.95	1.8	1.8
		C46	26	5 447	408 545	390 320	72	95.5	7.00	1.29	1.7	1.8

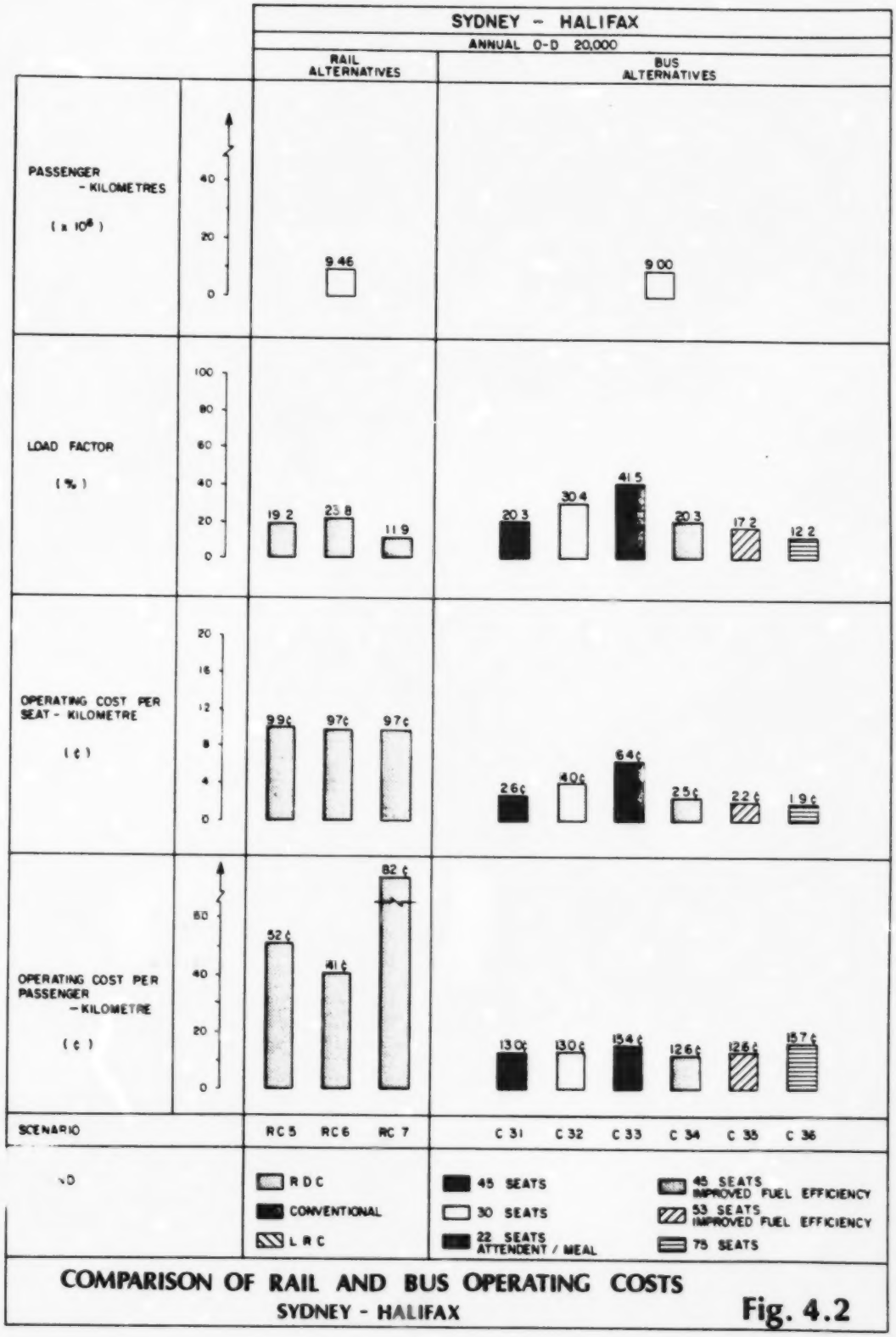
TABLE 4.3
OPERATIONAL AND COST PERFORMANCE OF BUS ALTERNATIVES
(Continued)

Link	Scen.	Daily Dep.	Veh. -Km (000's)	Seat -Km (000's)	Pass. -Km (000's)	Pass. Per Bus	Load Factor (%)	$Mill.	$Per Veh. -Km	¢Per Seat -Km	¢Per Pass. -Km
5. N. Vancouver - P. George	C51	6	1 763	79 333	12 075	7	15.2	1.99	1.13	2.5	16.5
	C52	6	1 763	52 889	12 075	7	22.8	1.99	1.13	3.8	16.5
	C53	6	1 763	38 785	12 075	7	31.1	2.38	1.35	6.1	19.7
	C54	6	1 763	79 333	12 075	7	15.2	1.90	1.08	2.4	15.7
	C55	6	1 763	93 436	12 075	7	12.9	1.91	1.08	2.0	15.8
	C56	6	1 763	132 221	12 075	7	9.1	2.33	1.32	1.8	19.3
6. Winnipeg - Thompson	C61	4	959	43 156	19 150	20	44.4	1.10	1.15	2.5	5.7
	C62	4	959	28 771	19 150	20	66.6	1.10	1.15	3.8	5.7
	C63	4	959	21 099	19 150	20	90.8	1.36	1.42	6.4	7.1
	C64	4	959	43 156	19 150	20	44.4	1.05	1.09	2.4	5.5
	C65	4	959	50 829	19 150	20	37.7	1.06	1.11	2.1	5.5
	C66	4	959	71 927	19 150	20	26.6	1.29	1.35	1.8	6.7
7. Winnipeg - Edmonton	C71	6	2 930	131 860	40 140	14	30.4	3.20	1.09	2.4	8.0
	C72	6	2 930	87 907	40 140	14	45.7	3.20	1.09	3.6	8.0
	C73	6	2 930	64 465	40 140	14	62.3	3.92	1.34	6.1	9.8
	C74	6	2 930	131 860	40 140	14	30.4	3.05	1.04	2.3	7.0
	C75	6	2 930	155 302	40 140	14	25.8	3.06	1.04	2.0	7.6
	C76	6	2 930	219 767	40 140	14	18.3	3.73	1.27	1.7	9.3



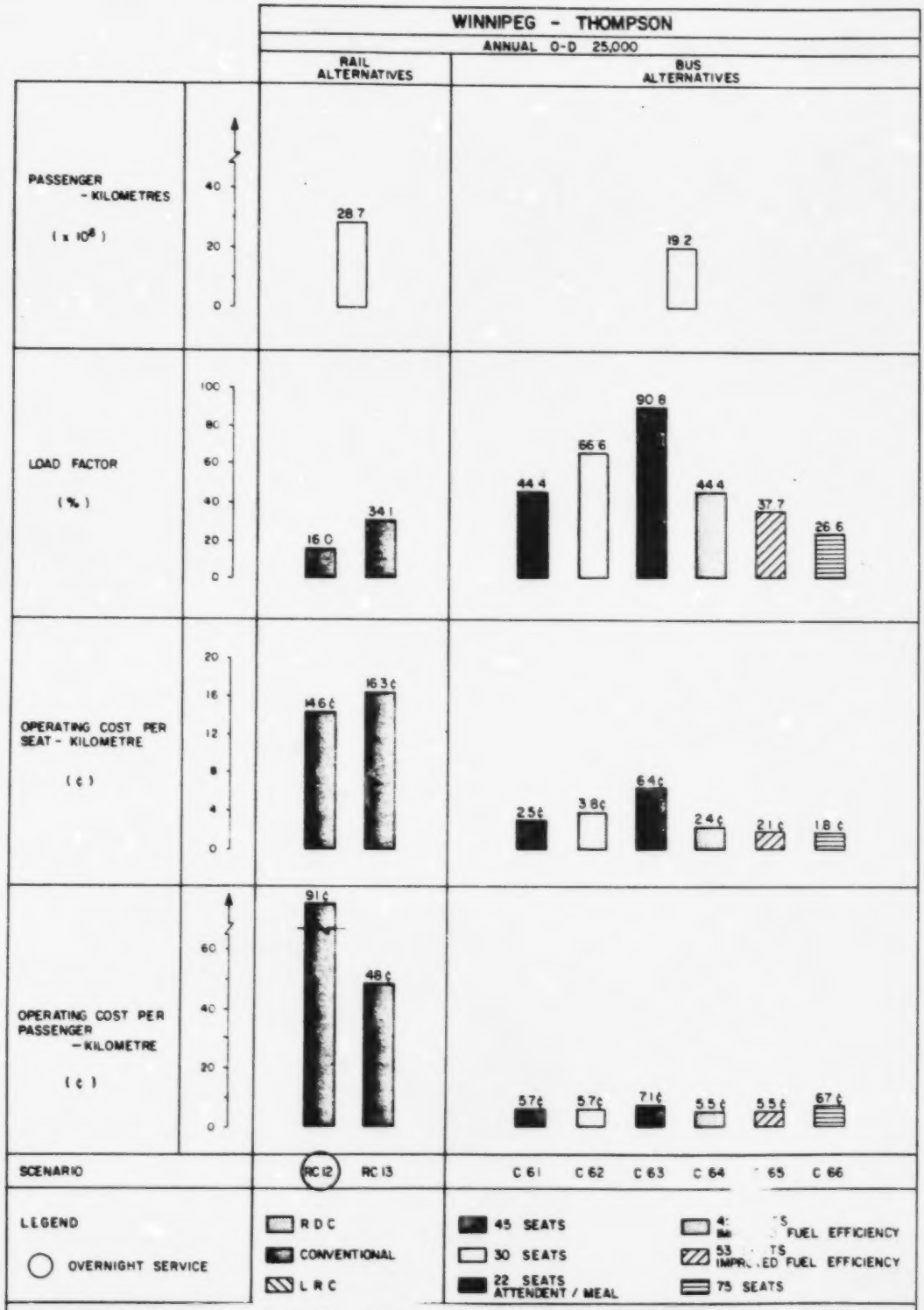
COMPARISON OF RAIL AND BUS OPERATING COSTS
N. VANCOUVER - P. GEORGE

Fig. 4.1



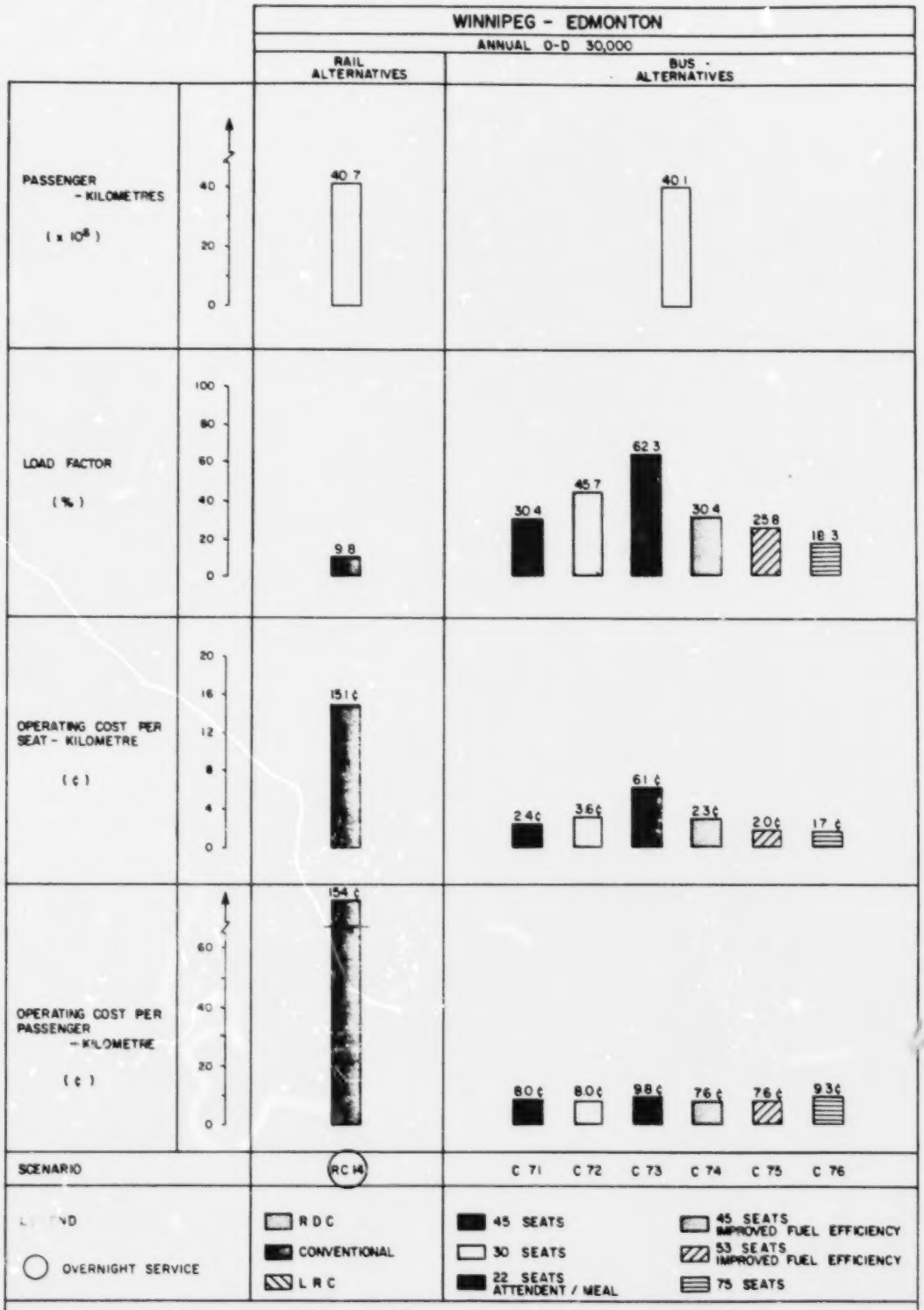
COMPARISON OF RAIL AND BUS OPERATING COSTS
SYDNEY - HALIFAX

Fig. 4.2



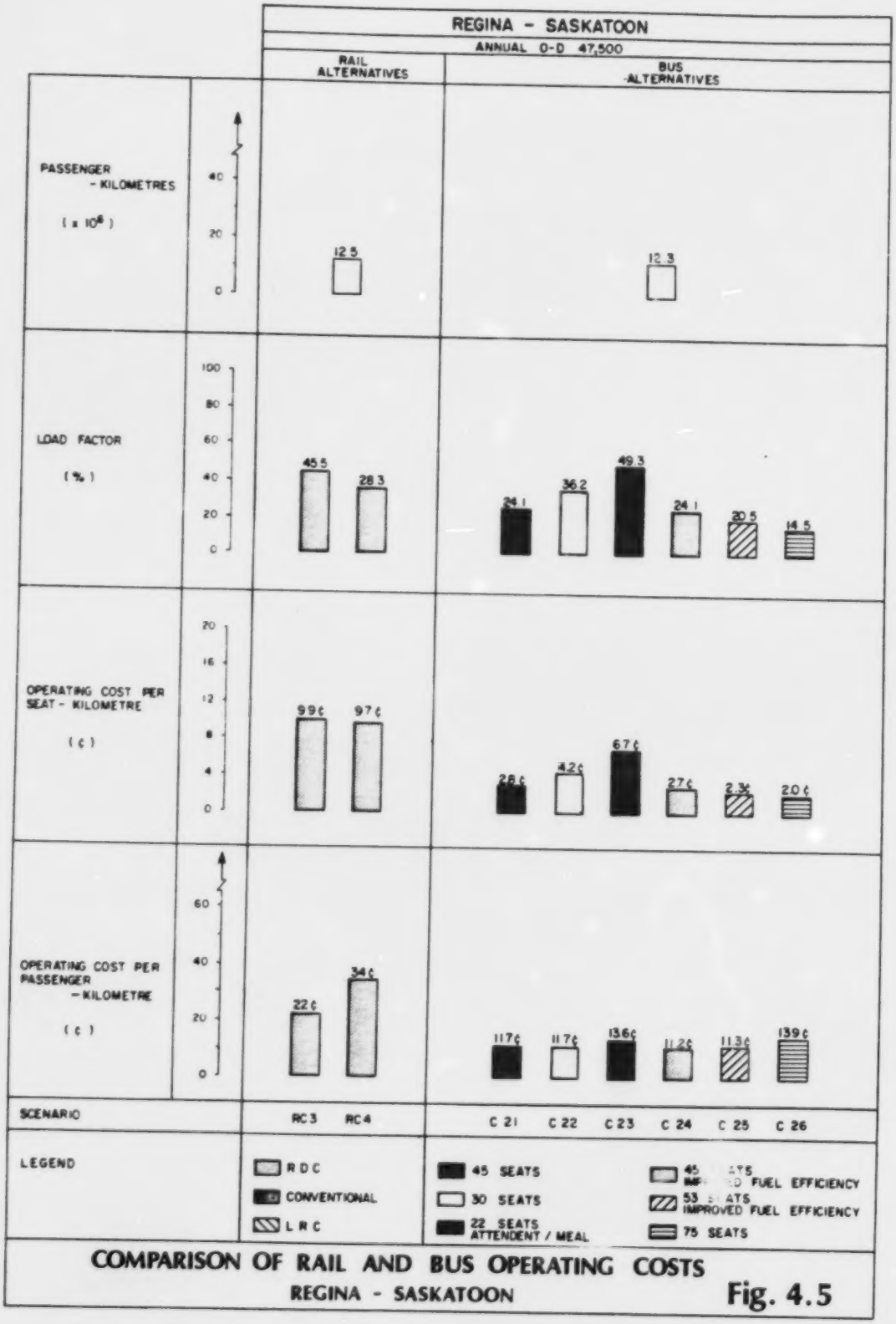
COMPARISON OF RAIL AND BUS OPERATING COSTS
WINNIPEG - THOMPSON

Fig. 4.3

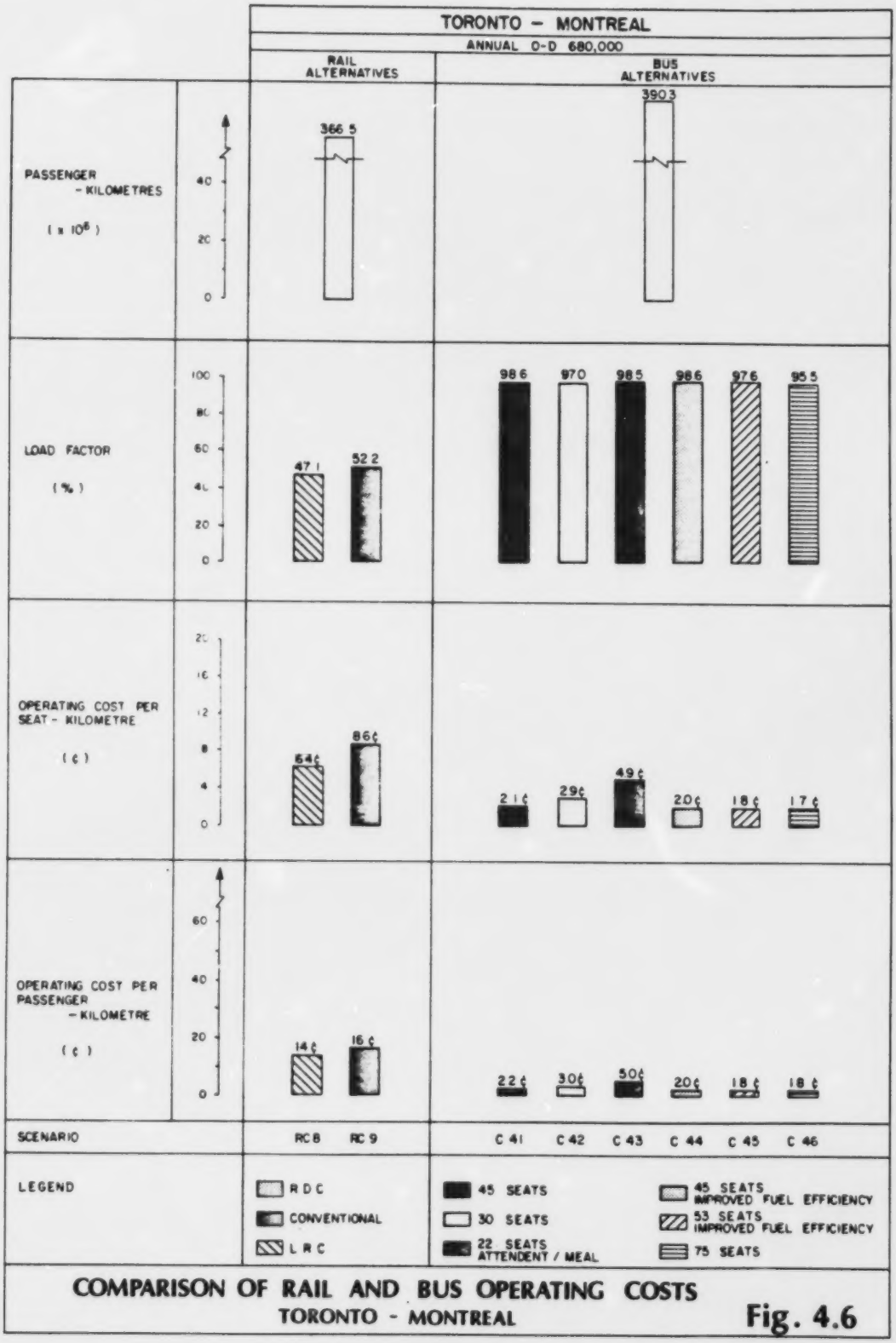


COMPARISON OF RAIL AND BUS OPERATING COSTS
WINNIPEG - EDMONTON

Fig. 4.4

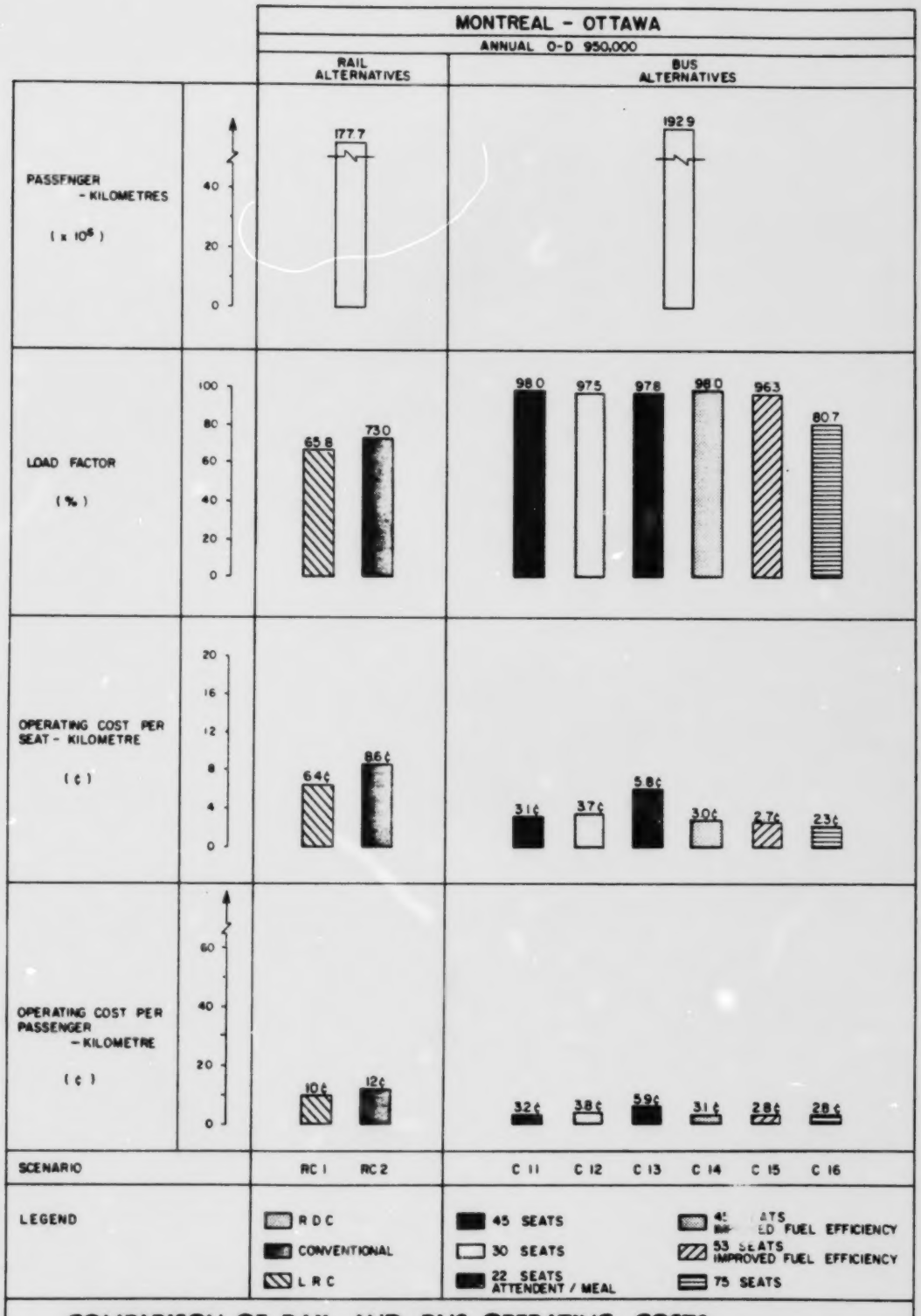


COMPARISON OF RAIL AND BUS OPERATING COSTS
REGINA - SASKATOON **Fig. 4.5**



COMPARISON OF RAIL AND BUS OPERATING COSTS
TORONTO - MONTREAL

Fig. 4.6



COMPARISON OF RAIL AND BUS OPERATING COSTS
MONTREAL - OTTAWA

Fig. 4.7

5. CONCLUSIONS

Rail

- The study confirms the most appropriate application of LRC equipment to be high density, short haul routes; of RDC equipment to be low density routes; and of conventional rail equipment to be overnight routes.

- The operating costs exhibited by LRC's are lowest. Those of RDC's are slightly higher. Highest costs are demonstrated by conventional rail equipment.

Bus

- The study confirms that significant economic savings can be achieved via a reduction in fuel consumption. Accordingly it is recommended that efforts should be directed towards the development of improved fuel efficient engines.

- It is concluded that there is a market for slightly larger buses (i.e. 53 seaters) and that the use of such vehicles on high density routes can reduce overall operating costs.

- A cost advantage may be achieved by operating reduced capacity vehicles which provide more space, comfort and possibly on-board meal services, on lower density routes provided that complementary marketing efforts are initiated.

Rail Bus

- It is concluded that rail is the more expensive of the two modes - regardless of route, service frequency or ridership.